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Study of the functions and responsibilities of a project management office to support university research centers

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Thank you.

STATEMENT OF INTEGRITY

I hereby declare having conducted this academic work with integrity. I confirm that I have not used plagiarism or any form of undue use of information or falsification of results along the process leading to its elaboration.

I further declare that I have fully acknowledged the Code of Ethical Conduct of the University of Minho.

RESUMO

Nos últimos anos, novas estruturas têm surgido dentro das organizações para melhorar a execução e o desempenho dos projetos, tais como o Project Management Office (PMO). O PMO é uma estrutura organizacional que tem como finalidade promover e melhorar as práticas de gestão de projetos, adotando metodologias apropriadas para atingir níveis altos de eficácia e eficiência. Um PMO é uma mais-valia quando bem implementado e já são vastos os estudos realizados sobre o conceito de PMO como estrutura de suporte às organizações. No entanto, pouca pesquisa foi realizada sobre o conceito de PMO dedicado ao suporte de centros de investigação.

O contexto organizacional dos centros de investigação, pela sua natureza, é diferente do contexto organizacional comum das organizações. Portanto, urge saber qual o tipo de PMO, as suas funções e responsabilidades e como este deve ser implementado dentro do contexto organizacional de um centro de investigação.

Assim sendo, esta pesquisa propõe-se a conceptualizar uma estrutura de PMO no contexto dos centros de investigação. Para tal, foi conduzido um questionário, a nível global, a investigadores de centros de investigação e realizado um conjunto de entrevistas a investigadores de centros de investigação da Universidade do Minho.

A pesquisa indica que existe recetividade por parte dos investigadores para a criação de estruturas de PMO nos seus centros de investigação e sugere a implementação de uma estrutura de PMO com um conjunto de funções e responsabilidades dividida em três tipos, com diferentes níveis entre si.

Uma vez que parte dos dados da pesquisa foram obtidos através da disseminação do questionário, houve dificuldade na obtenção de respostas por parte dos investigadores e, portanto, a taxa de resposta resultante foi baixa.

A pesquisa mostra que existe a necessidade de analisar adequadamente o contexto em que os centros de investigação se inserem e que as estruturas de PMO a implementar diferem do contexto comum das organizações.

PALAVRAS-CHAVE

Centros de Investigação, Funções do PMO, Gestão de Projetos, *Project Management Office* (PMO)

ABSTRACT

In recent years, new structures have emerged within organizations to improve project execution and performance, such as the Project Management Office (PMO). PMO is an organizational structure that aims to promote and improve project management (PM) practices, using appropriate methodologies to achieve elevated levels of effectiveness and efficiency. A PMO is an asset when well implemented and studies on the concept of PMO as a support structure for organizations are already extensive. However, very little research has been done on PMO structures dedicated to supporting university research centers (URC).

The organizational context of URC, by their nature, is different from the organizational context of other organizations. Therefore, it is important to know what type of PMO, its functions and responsibilities (F&R), and how it should be implemented within the organizational context of a URC.

Thus, this research proposes to conceptualize a PMO structure for URC. To this end, a questionnaire was conducted for researchers from URC around the world and a set of interviews were carried out with research staff of research centers from University of Minho.

Research indicates that researchers are receptive to the creation of PMO structures in their URC and suggest the implementation of a PMO structure with a set of F&R divided into three PMO typologies with different levels.

Since part of the data was obtained through the dissemination of the questionnaire, there was difficulty either in collecting or making available the contacts of the respondents or in getting answers from the respondents and, therefore, the response rate was quite low.

Research shows that there is a need to properly analyze the context in which URC operate and that the PMO structures to be implemented differ from the common context of organizations.

KEYWORDS

Project Management (PM), Project Management Office (PMO), PMO Functions, University Research Centers (URC)

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ACRONYMS AND ABBREVIATIONS

FA – Factory Analysis

F&R – Functions and Responsibilities

FCT – *Fundação para a Ciência e a Tecnologia*

KMO – Kaiser-Meyer-Olkin

MSc – Master of Science

PCA – Principal Component Analysis

PgMO – Program Management Office

PhD – Doctor of Philosophy

PI – Principal Investigator

PM – Project Management

PMBOK – Project Management Body of Knowledge

PMCoE – Project Management Center of Excellence

PMI – Project Management Institute

PMO – Project Management Office

PPM – Project Portfolio Management

PSO – Project Support Organization/Office

R&D – Research and Development

RO – Research Objective

SPSS – Statistical Package for the Social Sciences

URC – University Research Centers

1. NATURE AND SCOPE OF THE RESEARCH

1.1 Introduction

Current research into Project Management (PM) has stressed the importance of implementation of Project Management Office (PMO) structures in organizations as an organizational unit to act as repositories of learning and as vehicles enabling knowledge transfer to address competitive and globalized markets, as well as constant environmental changes and strategic goals that may require deep organizational restructuring of their business models. However, to decide which specific PMO Functions and Responsibilities (F&R) an organization should implement remains a major challenge for most organizations. As such, this chapter presents the documentation of the facts that allow to frame the topic proposed, as well as to define the objective and research question and, finally, the structure of this dissertation.

1.2 Research context

This research was undertaken through the academic environment to obtain the master's degree in Industrial Engineering, in the Project and Innovation Management and Evaluation expertise area at University of Minho.

During the participation in the master's degree the researcher was acquiring essential knowledge regarding PM and thus the desire to develop a deeper work in the area arose, namely in the concept of PMO. Through some research, the researcher noticed that the concept of PMO began to emerge in many organizational contexts, namely in business and construction companies, some of which wanted or were implementing a PMO structure in their context. But he also noticed the existence of few studies regarding the concept of PMO applied to organizations within the university context. One of these studies was a recent research that a colleague of his university conducted in order to investigate the context of the PMO applied to research centers in Portugal[1]. The researcher showed much interest in the subject and in the results obtained that decided to continue the study, extending the research to an international context, in order to verify if the results are the same or different. In essence, the researcher decided to investigate

[1] Ferreira, H. (2016). Conceptualização de estruturas de PMO em centros de investigação. University of Minho. Available in: http://hdl.handle.net/1822/47825

the concept of PMO, namely typologies, functions and responsibilities (F&R), applied to University Research Centers (URC).

In order to give context to the previous information, in the following the concepts of URC and PMO are briefly presented.

University research centers (URC)

URC can be defined as an organizational entity within a university that aims to serve a research mission, is separate from the departmental organization and includes researchers from more than one department (Bozeman & Boardman, 2003). These centers appeared to solve complex interdisciplinary problems (Sabharwal & Hu, 2013) and their main function is generating new knowledge that encompasses theories and application from disciplines that normally do not come together in traditional department-based academic settings (Boardman & Corley, 2008; Bozeman & Boardman, 2003; Stahler & Tash, 1994). The URC are public or private non-profit institutions dedicated to scientific research and technological development and represent a fundamental pillar in the consolidation of a modern and competitive scientific system. They must gather critical mass, appropriate to their mission, and promote creative environments where new ideas can emerge and where researchers find the right conditions to carry out their scientific projects and the development of their career.

The existing literature points out advantages and disadvantages for this type of entities. Some of the literature have shown that URC lead to positive outcomes for faculty members in the form of increased publication productivity (Bunton & Mallon, 2007; Corley & Gaughan, 2005; Ponomariov & Boardman, 2010), collaboration and networking (Boardman & Corley, 2008; Bozeman & Corley, 2004; Gaughan & Ponomariov, 2008), industry partnerships (Gaughan & Corley, 2010), and technology transfer (Bozeman & Boardman, 2003; Rogers, Hall, Steffensen, Speakman, & Timko, 1999; Youtie, Libaers, & Bozeman, 2006). By contrast, other articles suggest that URC can be a source of conflict between the values of academic departments and the interdisciplinary values that are often promoted in centers through commercial activities such as patenting (Kleinman & Vallas, 2001; Slaughter, Campbell, Holleman, & Morgan, 2002). In addition, being affiliated with a URC results in competition among faculty for resources such as time, research support, and infrastructure (Boardman & Bozeman, 2007; Boardman & Ponomariov, 2007; Stahler & Tash, 1994).

One of the main differences between a company and a URC is the form of financing (FCT, 2017). In companies, the most common forms of financing are bank credit, leasing, factoring, business angels and venture capital. In turn, in URC, funding can be provided through universities where they are integrated, through partnerships between industries and universities, or through national or community funds. In the case of Portugal, these units are evaluated and financed by the Portuguese national funding agency for science, research and technology (FCT). In Portugal, there are 305 R&D units with approved funding for the period 2015-2019 (FCT, 2019).

To address the increasingly complex nature of scientific problems, which requires research solutions that span disciplinary and institutional boundaries, URC are becoming more common (Boardman & Bozeman, 2007). The successful creation of research centers and institutes goes way beyond the changing needs and structures of universities. Another important reason is the need to bring researchers from several areas and ideologies to work together in an effort to solve complex scientific and social problems that cross disciplinary boundaries (Boardman & Corley, 2008; Bozeman & Boardman, 2003; Ikenberry & Friedman, 1972; Stahler & Tash, 1994).

Generally, universities and faculty members benefit from the presence of research centers. On the one hand, research centers can attract faculty to join by way of offering extra space, resources and additional funding opportunities (Mallon, 2006) and allow faculty members to further develop their research agendas within the university structure (Ikenberry & Friedman, 1972). On the other hand, research centers allow to improve the quality of university education, as they can help universities attract quality graduate students and improve overall graduate education (Ikenberry & Friedman, 1972; Rogers et al., 1999) while also facilitating interdisciplinary research and collaboration between experts from different disciplines (Boardman & Corley, 2008; Bozeman & Boardman, 2003; Stahler & Tash, 1994). Therefore, research centers are viewed as a platform for faculty members to focus more on their research agendas and gain resources that are not available through their academic departments (Bunton & Mallon, 2007; Gaughan & Bozeman, 2002).

Some research centers are housed within an academic department and adhere to the administration of the department. Other centers function as separate entities in the university and are governed by an external dean or other authority (Stahler & Tash, 1994), which shows that the functions and nature of the URC are not the same and can differ in their organizational structures and hierarchy within the university. But all URC help promote research which aids in the accumulation of scientific knowledge along with

providing opportunities for mentoring and increased publication productivity (Wen & Kobayashi, 2001; Youtie et al., 2006).

Project management office (PMO)

A PMO structure is defined as an organizational entity that has on its domain several responsibilities related to the management and coordination of projects. These responsibilities may range from providing PM support functions or responsibility for the direct PM (PMI, 2017).

The emergence of PMOs is associated with the increasing number and complexity of projects around the world (Marsh, 2000). This significant increase has generated new challenges that organizations need to deal with (Spalek, 2014). In response to that need, since the mid-1990s, PMOs have begun to expand and have grown significantly (Kerzner, 2018). This abrupt growth is explained by the fact that the projects are non-routine, transitory and insular in nature (Pellegrinelli & Garagna, 2009).

In this way, PMOs are characterized as dedicated and enduring organizational entities whose responses to organization's needs have been taken for granted by many advocates of PMOs. They are unique structural arrangements designed to fulfill a specific purpose. So, it can be argued the PMOs are unlikely to be generic in their characteristics and tend to have less in common, between the organizations, than PM processes (Pellegrinelli & Garagna, 2009).

1.3 Research question

In general, there is some academic research on PMO structures present in organizations as companies (Aubry, Hobbs, & Thuillier, 2007, 2008; Lee-Kelley & Turner, 2017; Pellegrinelli & Garagna, 2009), but there is a gap of knowledge about the conceptualization, functions and typologies of PMO structures from the point of view of URC.

As already mentioned in the previous section, there is a recent research that addresses this theme but in a very particular context, since the research is carried out only in Portugal. The research by Ferreira (2016) included the dissemination of a questionnaire by nine institutes of higher education in Portugal and counted with a number of 242 answers. Although the results of Ferreira (2016) present a conceptualization of a PMO structure, it was carried out taking into account a particular sample, so it is necessary to understand if the proposed solution is valid in a larger context, as is the international context.

In short, this research aims to identify a conceptualization, namely identify the F&R that a PMO must have to support URC.

The research question is thus framed as: How can PMO structures be developed to support project management in a specific URC context?

1.4 Research objectives

The aim of this research is to develop a conceptualization of a PMO structure to support URC, based on critical characteristics of the PMO, the organizational context and the experience of the researchers. In pursuit of the research aim, and taking into account the previous research carried out by Ferreira (2016), the research was guided by two main objectives:

> RO_1: To identify the main functions and responsibilities (F&R) associated with a PMO structure in URC contexts;
>
> RO_2: To validate the main functions and responsibilities (F&R) identified for a PMO structure in a specific URC context.

For the achievement of RO_1, the researcher made an in-depth study of the literature in order to understand if there are significant advance regarding the previous research carried out by Ferreira (2016). This study will result in either the validation of the conceptualization proposed by Ferreira (2016), if there are new updates in the literature; or else a new conceptualization taking into account the most current state of the literature.

Therefore, the researcher intends to extend the research carried out by Ferreira (2016) to the international context through the dissemination of the questionnaire worldwide. To this end, for the analysis of the results, the researcher will gather the data obtained in the Ferreira's research (2016) and group with the data obtained in his research and finally, he will compare the results obtained in Ferreira's research (2016) and the data obtained in his research. Then, through interviews, the researcher intends to validate the main F&R identified in the context of University of Minho, i.e., what researchers would consider to be most useful to be exerted in a PMO structure in their URC. With this results RO_2 is achieved.

1.5 Dissertation structure

This dissertation consists of six chapters; each chapter is devoted to cover a specific area of study and to cover the topic of research interest. The structure of the dissertation is designed as follows: Chapter 1,

Nature and Scope of the Research, provides the foundation and justification of the study theme, a statement of the research background, the context and research question and the research objectives. Chapter 2, Literature Review, focuses on the scientific works related to the topic and theme of this research. The literature review begins by presenting a brief account of the evolution of PM, including, the main concepts of PM, as is the case of definitions of project, PM and project performance. Then, this chapter addresses the main topics in the realm of PMO structures, such as, the historical background of the PMO and seeks to shed light on the Functions and Responsibilities (F&R) of the PMO in improving management approaches and project performance in executing the organization's projects. This chapter ends by presenting a proposal of the conceptualization of a PMO structure, with twenty-five F&R, resulting from the analysis of the vast academic research already developed. This information supports the questionnaire to be disseminated. Chapter 3, Research Methodology, describes in detail the methodology applied to explore the research objective 1. It is here that the grounds on which this research was developed, as well as the approaches, techniques and processes used are presented, namely, the design and dissemination process of the questionnaire and the interview questions' structure and respondents' selection. Both, Chapter 4, Findings, and Chapter **Erro! A origem da referência não foi encontrada.**, Case Study, address the data analysis connecting the results to the aim of the research. Finally, the Chapter 6, Conclusions and Further Research, closes the dissertation by highlighting the consistency of the generated findings with the proposed research question and hypotheses. Recommendations and suggestions for further research are made to fill the knowledge gap in the PMO literature, in particular, the conceptualization of PMO structures to support URC.

2. LITERATURE REVIEW

2.1 Introduction

History and context are essential for a clear understanding of what is observed at any point in space and time in complex systems such as organizations (Engwall, 2003). Consequently, this chapter presents a review of relevant literature concerning PMOs. According the 2018 edition of the PMI's *Pulse of the Profession*[2] report (PMI, 2018), 68% of the respondents have a PMO in their organization, but only 58% of organizations fully understand the value of project management. It is worth noting that organizations that undervalue project management as a strategic competency for driving change report an average of 50% more of their projects failing outright. So, in this sense, this chapter intends to identify the different responsibilities, functions and structures of PMOs used in the organizational context that contribute to the increase of the performance of the PM and consecutively to the improvement of the organizational performance. The review seeks to group the main F&R that PMOs might adopt based on the critical characteristics of the PMO and the organizational context. Through the literature review will arise the initial conceptualization of a PMO structure to support a URC that will serve as the basis for the development of this research.

Before understanding what a PMO is, it is required to know well what a project is. To do that, this chapter begins by providing a clear understanding of what project, project management and project performance are. Following this, the main information about the PMO context is presented, such as, a brief description of the PMO concept, a presentation of the main structures and typologies existing and defended by several authors, as well as their F&R associated with their structures. Finally, taking into account the literature regarding the PMOs F&R, an initial conceptualization of a PMO with three types of PMOs is developed and serves as the basis for the development of this research.

2.2 Definitions

Following are brief definitions of project, PM and project performance.

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[2] PMI's *Pulse of the Profession* is the premiere global survey of professionals who provide project, program, or portfolio management services within organizations. The 2018 edition of the Pulse highlights feedback and insights from 4,455 project management practitioner from a range of industries, including government, information technology (IT), telecom, energy, manufacturing, healthcare, and construction.

Project

According Project Management Institute (PMI) (2017, p. 4), a project is defined as a *'temporary endeavor undertaken to create a unique product, service, or result'*. As evidenced by the term 'temporary' used in the project definition, each project by nature has a specific duration, with a well-defined beginning and end. Others definitions view a project as a complex sequence of activities to deliver clearly defined objectives (Turner & Cochrane, 1993). A project is an activity that could not be implemented without organizational procedures (Kerzner, 2009). To achieve the project's objectives it is necessary to have well-defined processes, otherwise it is very difficult or almost impossible to achieve project's objectives (Liberato, Varajão, & Martins, 2015). Well-executed projects meet stakeholders needs and expectations (Walker & Nogeste, 2008).

It is with the thought in the well-defined processes to ensure the well execution of projects that emerge the management models, at the end of the 1950s, through standardized tools, practices and roles (Garel, 2013), thus ensuring a more effective management of the projects (Dvir, Shenhar, & Alkaher, 2004).

Project management

Project management (PM) has been recognized by those who use it, both in the academic and business world, as an important and interesting tool with many advantages (Mir & Ashly H. Pinnington, 2014). However, while there is a growing interest in the study and development of this subject, it remains difficult to quantify the real value of project management to projects, employees, organizations and the community. The entire PM process involves the application of knowledge, skills, tools and techniques to the project activities, in order to achieve their goals (PMI, 2017). While it is a continuous challenge to achieve effective and high-level PM, organizations are committed to its transformation and adaptation. An organization can only achieve added value (Too & Weaver, 2014), increase productivity and improve business performance of resources (Jalal & Koosha, 2015) with continued investment in high-level projects, where a close relationship between project results and business strategy requirements is made. PM, besides having the purpose of delivering the final project in terms of time, cost, scope and quality requirements, aims to create business value (Aubry et al., 2007). The true nature of PM is in the understanding of this premise. Only in this way organizations can maximize the value of the work carried out. The implementation of a new entity, the Project Management Office (PMO), in the organizational project governance, demonstrates the effort that organizations are making to adapt and evolve in order to create value (Hobbs, Aubry, & Thuillier, 2008).

Project performance

For several decades, researchers or simply project team members have attempted to improve project performance by adopting project-based management and improve the competence of project team members through the development of new PM tools and techniques (Besner & Hobbs, 2012; L. Crawford et al., 2008; Flyvbjerg, Bruzelius, & Rothengatter, 2003; Hebert & Deckro, 2011; Packendorff, 1995; Sauer & Reich, 2009).

As Liu and Yetton (2007) suggest, project performance is essentially the result of the comparison between measuring the actual current project status and the project output control mechanisms predicted at the measurement date, such as targets/milestones or deliverables. Thus, the success of project management is usually measured by achieving the scope, time and cost criteria, which was known as the triple constraint or the iron triangle (Atkinson, 1999; Gray & Larson, 2014; Schwalbe, 2019). Consequently, Um and Kim (2018) argue that the focus of the development of project performance is placed on effectiveness and efficiency.

One must bear in mind that the greater the uncertainty reduction in project activities, the greater the improvement in project performance. So, the conceptualization of overall project performance includes the performance of all of its activities, such as the performance of the schedule, quality, innovation, benefits, among others (Barki & Hartwick, 2001; Gelbard & Carmeli, 2009). Because that, nowadays, several authors suggest that there is an increasing interest in analyzing and identifying critical aspects of project performance in corporations (Chen, 2014; Henderson, Stackman, & Lindekilde, 2016; Maurer, 2010; Park & Lee, 2014; Shazi, Gillespie, & Steen, 2015).

2.3 Project Management Office

Projects are increasingly in pursuing the strategic goals of organizations (Aubry et al., 2007) and PM has had an increasing importance in the management of organizations because PM offers an opportunity for a pragmatic approach to planning for future needs and are an opportunity to think outside the box and innovate with new approaches to solving problems (Phan, 2015). As part of the response to these new challenges, Project Management Office (PMO), as a new organizational entity, arises from the fact that many organizations feel the urge to implement a structure that supports the increase in the number and strategic importance of projects (Aubry, Hobbs, & Thuillier, 2009; Hobbs et al., 2008).

As mentioned above in section 1.2, a PMO is a structure that arises due to high number and complexity of projects and whose function is to support project management in organizations. Therefore, it can be said that organizations and, consequently, the PMO structures are constantly changing. Schumpeter's process of creative destruction (Fukuyama & Schumpeter, 1997) provides a useful analogy to describe this phenomenon. Through an economic view of innovation, Schumpeter says that the capitalist system can be understood as the evolutionary process where industries constantly evolve and firms adapt through the process of creative destruction.

Aubry et al. (2008) suggest that from a contingency perspective, the PMOs adapt to their environment. This being a dynamic and intertwined process between strategy and structure (Chandler, 1990; Pettigrew, 2003). There is a bidirectional relationship between the PMO and the organization in which it operates: they adapt and evolve together. In this approach, the PMO in a given period is seen as a temporary state resulting from previous events and participates in the development of the future. This approach has been used to explore the PMO as an organizational innovation (Hobbs et al., 2008).

Organizations should be well advised when deciding to implement a PMO. They should not decide based on simple mistaken or unfounded assumptions about the value of the money it generates or the fact that the PMOs have become popular (Brian & Aubry, 2007).

The implementation or reconfiguration of a PMO is an important organizational change. Usually this change is part of a broader organizational reconfiguration. It requires a methodology and an interpretive framework that can capture the complexity of organizational change (Aubry, Müller, Hobbs, & Blomquist, 2010).

For these reasons, the goal of this research was to study the ideal conceptualization that a PMO structure must have to support the project management in a URC. The research showed that, to understand a PMO one must take into account the context in which the PMO is inserted and the evolution of the same context (Aubry et al., 2008). Although PMO structures are an important feature in project management organizations, the underlying logic that leads to their implementation or renewal is not yet understood (Aubry et al., 2010). Noteworthy, there is no single guidebook on how to successfully establish and run PMOs in organizations. PMOs are different in size (from single person 'departments' to entities with hundreds of people) and there can be just one or several PMOs in different places of an organization's organizational structures, supporting business, operational or strategic activities (Spalek, Kuhn, & Dayton, 2016). The normative presumptions of longevity and the obvious creation of value and the descriptions

of the generic types of PMOs appear to be in divergence with actual practice, offering neither a solid theory nor a pragmatic orientation to managers (Brian & Aubry, 2007).

There are varieties of interpretations of what the PMO is and what it really should be (Pemsel & Wiewiora, 2013), particularly because the complexity and variety that PMOs have assumed. Despite this, all definitions have a common feature, since the objective of a PMO is to support PM and increase its effectiveness. However, it is important to note that the effectiveness and success of a PMO depends on the choice of F&R to be implemented and their adaptation and adjustment to the organizations' needs (Fernandes, Pinto, Araújo, & Machado, 2018; Hurt & Thomas, 2009; Pansini, Terzieva, & Morabito, 2014; Pinto, Cota, & Levin, 2010).

Due to the different structural and contextual dimensions of each organization, it is feasible to have different PMOs in structural and functional terms. Regarding that this notion is essential to achieving efficient PMOs (Jalal & Koosha, 2015), the main typologies of PMOs defended by several authors and which can be found in the literature are presented below.

2.4 Typologies of PMOs

It is noted that, in order to increase the performance of the projects and to meet the different expectations, when implementing a PMO, there is a need to adapt its characteristics, F&R to the organizational and strategic context (Cunha & Moura, 2014). So, the main challenge for organizations is to ensure the alignment of PM with the strategic objectives. For that it is important to reconcile the internal management of the projects with governmental structures (Too & Weaver, 2014).

Desouza and Evaristo (2006) argue that there must be different PMOs for different companies' branches and for different companies' geographical locations, because companies operating in different lines of actions and in different regions or even different countries should have PMOs that understand the needs and requirements of those lines of actions and regions/countries.

In view of the above, the PMO and the organization must adapt to the necessary changes that will help achieve those goals (Hurt & Thomas, 2009) and each organization should consider what role its PMO should play and adapt its functions to the needs to which the PMO must respond (Fernandes et al., 2018).

Several authors have proposed models and typologies to classify the services offered by a PMO structure (Pansini et al., 2014) and every model presents a set of F&R that a PMO structure should performs. The

F&R of a PMO are subject to various configurations, established to ensure the transmission of knowledge and the achievement of objectives and actions to achieve goals (Aubry et al., 2007).

As can be verified in the literature, PMOs, in general, are quite heterogeneous: they vary in size, functions and other aspects (Müller, Glückler, & Aubry, 2013). In fact, as described below, the PMOs structures are often summarized in typologies comprising models (Monteiro, Santos, & Varajão, 2016).

The researcher identified a total of 55 PMO models comprised by 15 typologies. Those various models and typologies found among the analyzed literature are presented in Table 1. The order in which they are presented takes into account the date of the reference, from the oldest to the most recent. It was verified that the most common typologies have three types, in which each type is a model of a PMO. Therefore, it can be verified that the common typology, from which most definitions of typologies originate, comes from PMI (2017).

In the following sections a brief description of the characteristics of each PMO typology is presented (see Table 1).

Typology 1: Englund et al., 2003

Englund et al. (2003) have identified three PMO models with different F&R. The first, *Project Support Office (PSO)*, works as a consulting entity who provides project management activities, such as planning, project management tools and document management. The second, *Project Management Center of Excellence (PMCoE)*, ensures that the methodologies and skills necessary for the project management are up-to-date, such as standardization processes, identification of best practices and training. The third, *Program Management Office (PgMO)*, have complete authority over the projects. This means that they have the responsibility to select project managers, to do project selection, and to promote the alignment of priorities with the business strategies.

Typology 2: Kendall and Rollins, 2003

Kendall and Rollins (2003) presented four PMO models. The first, *Project Repository*, ensures that the organization adopts a set of tools for project management and reporting. The second, *Project Coaching*, is an extension of the first and provides services and assistance to project managers, such as training and mentoring. The third, *Enterprise PMO*, regardless the project size, assumes the governance of the projects in which this model is involved. The fourth, *Deliver Value Now*, acts at a higher level, focusing in the Project Portfolio Management (PPM).

Typology 3: Garfein, 2005

Garfein (2005) proposed four models too. The first, *Project Office*, has as function organize project data to provide to a higher oversight authority for consolidation. The second, *Basic PMO*, complies data from multiple projects. The third, *Mature PMO*, has the capability to manage resources and develops methods for prioritizing projects. And the fourth, *Enterprise PMO*, has the responsibility to take decision over the projects and is at the level of PPM.

Typology 4: Letavec, 2006

Letavec (2006) presented three PMO models. The first, *Consulting PMO*, is responsible for promoting and sensitizing the organization's workers for PM activities. The second, *Knowledge PMO*, has control over the standards and processes that govern the projects in the organization and has the function of building best practices in PM. Finally, the third, *Standard PMO*, works as a center of expertise for PM in organizations and seeks the benefit of the entire project community through the provision of consulting services, such as training, mentoring and standards-setting activities.

Typology 5: Desouza and Evaristo, 2006

Desouza and Evaristo (2006) presented four PMO models. The *Supporter* performs administrative functions, such as providing project status and identifying risks. The second, *Information Manager*, serves as a source of information of the projects' progress. It is a knowledge intensive PMO with a partial administrative function. The third, *Knowledge Manager*, is a repository of best practices and provides expert project knowledge, guidance and training. It is recognized as an authority on knowledge related to PM but has no administrative responsibility. Finally, the last model, *Coach*, knows the state of the projects in the organization and ensures the use of best practices to maximize the effort of projects.

Typology 6: Gartner Research Group, 2008

Gartner (2008) proposed five PMO models. The first, *Project Support Office (PSO)*, should provide life cycle support, resourcing, scheduling, scoping and hands-on project assistance or mentoring at the requirements and planning stage of the project. The second, *PMO*, seeks to establish a consistent baseline of processes in projects, adding formalized project tracking and reporting. The third model, *Project Management Center of Excellence (PMCoE)*, provides guidance to people by increasing the skills and sharing of tacit knowledge among projects managers in order to increase project efficiency. The

fourth model, *Federated PMO*, consists of a corporate PMO and a number of operating PMOs where the corporate PMO takes responsibility for methods, training and tools while the operating unit PMOs are directly responsible for project reporting, oversight or even delivery. Lastly, the fifth PMO model, *Enterprise PMO*, concerns itself with the reporting and oversight of major company initiatives and, in some cases, can be expanded to include functioning as a strategy support office with responsibility for scenario planning and strategic analysis.

Typology 7: Singh et al., 2009

Singh et al. (2009) only presented two PMO models, classified as extreme: (1) *Light* and (2) *Heavy*. The *Light* PMO performs a passive role and supports the project managers, only creating models for the implementation of projects and acting as an information repository. This PMO has no control over the projects. At the other extreme, a *Heavy* PMO is an essential complement to PM, even having direct control over projects.

Typology 8: Kerzner, 2009

Kerzner (2009) presents three types of project offices that are commonly used in companies: (1) *Functional*, (2) *Customer Group* and (3) *Corporate (or Strategic)*. The first one is utilized in one functional area or division of an organization and his major responsibility is to manage critical resources. This PMO may or may not actually manage projects. The second type of project office is for better customer management and customer communications. Common customers or projects are clustered together for better management and customer relations. This type of PMO will have a permanent project manager assigned and managing projects. Finally, the third type serves the entire company and focuses on corporate and strategic issues rather than functional issues.

Typology 9: J. K. Crawford, 2010

Crawford (2010) proposed three PMO models: (1) *Type 1*, (2) *Type 2* and (3) *Type 3*. The first, *Type 1*, is focused on controlling and monitoring the schedule, budget and other administrative aspects. The second, *Type 2*, has the role of integrating different projects of different sizes into one unit of one or more project portfolios. This PMO model, besides focusing on the success of the projects, also focuses on the use of the processes for other projects and divisions, allowing a greater level of efficiency in resource

management. The third, *Type 3*, is positioned at the corporate level which supports the top management in the prioritization of the projects, in order to support the strategy and objectives of the company.

Typology 10: Unger et al., 2012

Unger et al. (2012) presented three PMOs models. The first, *Supporting*, aims to support project members and project managers during project execution, promoting and enabling the use of PM standards in the organization. The second, *Controlling*, manages the information to be applied by decision makers. This information should be established as reliable, specific, accurate and up-to-date information on the status of projects. The third, *Coordinating*, includes project evaluation and selection, project support, departmental coordinator and improves the collaboration between all stakeholders.

Typology 11: Müller et al., 2013

Müller et al. (2013) proposed a conceptual framework with four PMO models (see Figure 1) that capture relationships between PMOs based on three base roles: serving, controlling and partnering. The first, *Superordinate*, is characterized by control and partner functions and is the profile that is positioned highest in the organizational hierarchy. The second, *Subordinate*, performs service orientation by supporting all PM initiatives within the organization. The third, *Coequal*, is a profile with equality and cooperation. Finally, the fourth, *Balanced*, appears at the center part of the triangle, and reflect equilibrium in the intensity of controlling, serving and partnering.

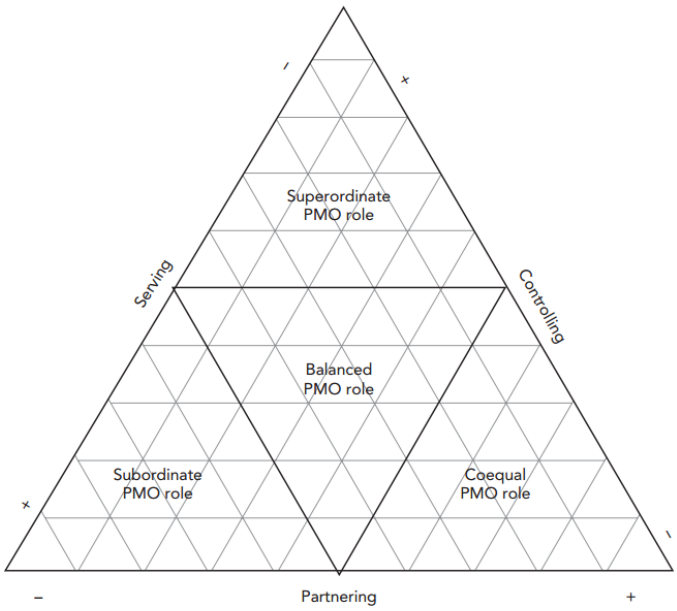

Figure 1 – The PMO triangle
(Müller et al., 2013)

Typology 12: Hill, 2013

Hill (2013) presented five PMO models. The first, *Strategic Office*, provides tools for the project manager and the ability to ensure professionalism and excellence in applying good project management practices appropriate to each project. The second model, *Basic PMO*, deals with managing multiple projects, taking into account the performance of the multiple project managers. The third, *Standard PMO*, introduces centralized supervision and control and motivates the evolution of PM by taking PM as the center of activity. The fourth, *Advanced PMO*, has as main objective to integrate the interests and the organizational objectives in the management of projects. Lastly, the fifth model, *Center of Excellence*, is the one that will be considering the organization's strategy, providing guidance to influence the organization's project management activities.

Typology 13: PMI, 2013

The PMI (2017) presents three different PMO models, with different levels of authority and control over the projects. The first, *Supportive*, has low degree of control and operates as a service unit, providing templates, access to good practices and access to information and lessons learned that derive from other projects. The second, *Controlling*, has moderate degree of control and implements standardized project management methodologies and tools adapted to the reality of the organization. Finally, the third, *Directive*, has high control over the project and assumes responsibility for all projects, being directly responsible for their management.

Typology 14: Hubbard and Bolles, 2015

Hubbard and Bolles (2015) note the majority of PMOs fit into one of seven different categories or types: (1) *Enterprise PMO*, (2) *Division PMO*, (3) *Business Unit PMO*, (4) *Project PMO*, (5) *Project Office*, (6) *Project Support Organization/Office (PSO)* and (7) *Project Management Center of Excellence (PMCoE)*. They suggest that the number of project management units within each layer will depend upon the size of the enterprise, the number and the complexity of the projects within the various levels of the enterprise. For small and medium-sized organizations, the number of functional units should be adjusted to the amount of control required by the enterprise, for the activity related to the project, at each organizational level. They also argue that of the seven identified types of PMO models, only four meet the full definition of a PMO, and only two of those are effective on an enterprise-wide and enterprise-level basis. PMOs located below the enterprise or division level have little influence on an enterprise-wide basis. *Project*

Office and *PSO* organizations as well as *PMCoE* do not manage projects and therefore are not actually a PMO. *PMCoE* are of value for developing and disseminating company-standardized project management practices at any level where they are used. However, the actual application and enforcement of those practices and process requires a PMO at the enterprise, division, or business unit level. PMOs located at the *Business Unit* level are effective within the business unit but lack the strategic and tactical aspects needed to have an influence outside of the *Business Unit*.

Typology 15: Aubry and Brunet, 2016

In a specific context of public administration, Aubry and Brunet (2016) proposed a conceptual framework for the categorization of PMOs based on types of project: (1) *Engineering and Construction*, (2) *Information Systems and Technology*, (3) *Business Processes* and (4) *New Product/Service Development*. The findings presented in their article suggests that this PMO categorization system has the potential to support the organizational design of PMOs in organizational characteristics, project characteristics, functions and performance.

Table 1 – Typologies of PMOs

Authors	Types of PMOs						
Englund et al., 2003	PSO	PMCoE	PgMO				
Kendall and Rollins, 2003	Project Repository	Project Coaching	Deliver Value Now				
Garfein, 2005	Project Office	Basic PMO	Mature PMO	Enterprise PMO			
Letavec, 2006	Consulting PMO	Knowledge PMO	Standard PMO				
Desouza and Evaristo, 2006	Supporter	Information Manager	Knowledge Manager	Coach			
Gartner Research Group, 2008	PSO	PMO	PMCoE	Federated PMO	Enterprise PgMO		
Singh et al., 2009	Light	Heavy					
Kerzner, 2009	Functional	Customer Group	Corporate/ Strategic				
J. K. Crawford, 2010	Type 1	Type 2	Type 3				
Unger et al., 2012	Supporting	Controlling	Coordinating				
Müller et al., 2013	Superordinate	Subordinate	Coequal	Balanced			
Hill, 2013	Strategic Office	Basic PMO	Standard PMO	Advanced PMO	Center of Excellence		
PMI, 2013	Supportive	Controlling	Directive				
Hubbard and Bolles, 2015	Enterprise PMO	Division PMO	Business Unit PMO	Project PMO	Project Office	PSO	PMCoE
Aubry and Brunet, 2016	Engineering and Construction	Information Systems and Technology	Business Processes	New Product/ Service Development			

2.5 Initial conceptualization of a PMO structure

All possible literature in the context of this research was collected and analyzed in order to obtain the maximum possible update to the subject. As criterion the research was done mostly in English and the publication period, even if it had not been previously established, was mainly between 2008 and 2018. The researcher performed some general searches using databases available to him, such as, ScienceDirect (www.sciencedirect.com), Emerald (www.emeraldinsight.com), Scopus (www.scopus.com) and b-on (www.b-on.pt). The researcher used the following terms and synonyms in his searches: *'project management office', 'pmo', 'project management', 'pmo model', 'pmo typologies', 'pmo functions', 'pmo roles', 'research institutions', 'research centers', ' research units' and 'university research centers'*. It was clear that relevant articles have been published in a variety of journals, highlighting the Project Management Journal and International Journal of Project Management.

Through the literature review came the initial conceptualization of the PMO structures to support URC. This initial conceptualization served as the basis for the development of the questionnaire.

As can mentioned above, although the number of PMO typologies in the literature is more extensive (Monteiro et al., 2016), with only those presented here it is already possible to realize that almost all of them are based on the basic functions presented by PMI (2017). That is, they are always typed according to support, control and direction functions. What happens is that different authors create different models with slight variations that they consider more appropriate, because, as mentioned by Monteiro et al. (2016), any model is necessarily a simplification and a reduction of the complexities of organizational reality and context.

Ferreira (2016) in her research also proves the information described above. In her analysis of literature, Ferreira only describes 7 PMO typologies, while in this research the researcher presents 15 PMO typologies. However, the researcher concludes that even having identified more typologies of PMO than those presented by Ferreira, it is possible to notice that practically all typologies are based on the typologies proposed by PMI (2017).

Likewise, when analyzing all proposed F&R for each PMO typology, the researcher was unable to find or propose new ones when compared to those proposed by Ferreira (2016). Through the intense analysis of the literature, the researcher confirms all the F&R presented by Ferreira (2016) and reinforces them with more references from other authors (see Table 2).

In summary, based on literature, a typology was proposed, with three types of PMOs: *Basic PMO*, *Intermediate PMO* and *Advanced PMO*, with different F&R. This conceptualization presents a logical evolution, with functions attributed to each PMO, implying that the PMO is supposed to evolve in all PM tasks, not fixing itself in a typology.

Table 2 presents the functions assigned to each of the types, indicating the bibliographic references where each of the functions was identified. The order in which each of these functions appears is not random and should be the starting point for each level. What distinguishes one type from another is (1) the growing importance of the PMO in the organization, (2) a greater number of responsibilities and (3) the positioning of the PMO in the organizational strategy.

Table 2 – PMO typology, F&R based on literature

PMO Type	Nº	PMO F&R	References
Basic PMO	FR1	Knowledge management: • Knowledge transfer • Increase knowledge about previous projects • Develop and manage files with project information • Lessons learned repository	(Dai & Wells, 2004; Desouza & Evaristo, 2006; Pellegrinelli & Garagna, 2009; Pemsel & Wiewiora, 2013; Winter, Smith, Morris, & Cicmil, 2006)
	FR2	Capture and disseminate good practices in project management	(Desouza & Evaristo, 2006)
	FR3	Provide well-trained project managers and teams (through training, workshops and seminars)	(Artto, Kulvik, Poskela, & Turkulainen, 2011; Dai & Wells, 2004; Desouza & Evaristo, 2006; Kwak & Dai, 2000; Pemsel & Wiewiora, 2013; Singh et al., 2009)
	FR4	Promote social and informal interaction	(Kerzner, 2009; Pemsel & Wiewiora, 2013)
Intermediate PMO	FR5	Develop methodologies (standards, procedures and tools)	(Cunha & Moura, 2014; Desouza & Evaristo, 2006; Kwak & Dai, 2000)
	FR6	Build a knowledge platform: • Ensure that projects consult the lessons learned • Post-project evaluation services	(Cunha & Moura, 2014; Desouza & Evaristo, 2006; Kwak & Dai, 2000)
	FR7	Provide periodic advice and guidance	(Cunha & Moura, 2014; Desouza & Evaristo, 2006; Kwak & Dai, 2000)

PMO Type	N°	PMO F&R	References
	FR8	Monitor and control project performance	(Cunha & Moura, 2014; Desouza & Evaristo, 2006; Kwak & Dai, 2000)
	FR9	Risk management (identify risks and main problems)	(Dai & Wells, 2004; Desouza & Evaristo, 2006; Kerzner, 2009; Kwak & Dai, 2000)
	FR10	Support projects (support the decision-making process)	(Cunha & Moura, 2014; Kwak & Dai, 2000)
	FR11	Supervision within the organization (monitor, summarize and report on project progress)	(Pellegrinelli & Garagna, 2009; Singh et al., 2009)
Advanced PMO	FR12	Strategic management: • Ensure that the accepted projects are aligned with the organizational strategy • Align the needs of the project with those of the organization	(Cunha & Moura, 2014; Desouza & Evaristo, 2006; Kerzner, 2009)
	FR13	Evaluation, analysis and projects selection (provide interpretative assessments)	(Artto et al., 2011; Cunha & Moura, 2014)
	FR14	Control and quality assurance	(Pemsel & Wiewiora, 2013)
	FR15	Project financial management: • Monitor projects in terms of budget and time • Provide administrative support to projects	(Pemsel & Wiewiora, 2013)
	FR16	Close monitor and control of projects	(Artto et al., 2011)
	FR17	Human resource management: • Balancing skills • Ensure team cohesion with the project manager	(Dai & Wells, 2004; Müller et al., 2013; Pemsel & Wiewiora, 2013)(Dai & Wells, 2004; Kerzner, 2009; Müller et al., 2013; Pemsel & Wiewiora, 2013)
	FR18	Project portfolio management (PPM)	(Dai & Wells, 2004; Kerzner, 2009; Müller et al., 2013; Pemsel & Wiewiora, 2013)

3. RESEARCH METHODOLOGY

3.1 Introduction

This chapter discusses the research methodology used for achieving the research aim and objectives stated in Chapter 1. A research can be defined as a study or systematic investigation that people undertake in order to establish facts and conclusions. With this in mind, it is necessary to understand the difference between the terms: methodology and method. Saunders et al. (2016) use the term methodology to refer to the theory of how research should be undertaken and use the term method to refer to techniques and procedures used to obtain and analyze data. So, research methodology represents the complex of approaches, techniques and processes on which research is based and it includes brief overview of how the collected data is analyzed and reported. Neumann (2011) defines a research methodology as a research in which the methods to be used to collect and analyze data are specifically delineated.

The purpose of the research methodology is to provide the researcher with indications for planning the best way to conduct the research. The researcher, to guarantee the quality of the research, adopts a generic framework described by Saunders et al. (2016). The research onion presents a structure with a framework for the most suitable methods and strategies that helped the researcher in addressing the research aim and objectives. Figure 2 illustrates the research onion as proposed by Saunders et al. (2016).

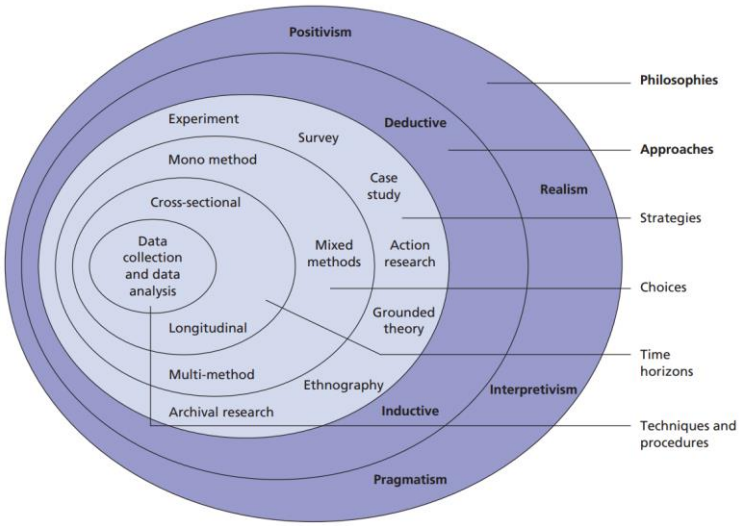

Figure 2 – Research onion
(Saunders et al., 2016)

As suggested in the research onion, the following aspects were covered:

i. Research philosophy
ii. Research approach
iii. Research strategy
iv. Time horizons
v. Techniques and procedures

In summary, this chapter provides an outline of the plan of action that was followed during the research and discusses in detail the research methodology. The chapter is divided into ten sections. Following the Saunders et al. (2016)'s research onion, the next section describes the research philosophy used. The third section defines the research approach and the fourth section presents the research strategy. The fifth section discusses the time horizons. The sixth section presents the data collection methods. The seventh section defines the research reliability and validity, and the eighth section discusses the population and sample. The last two sections discuss ethical and limitations of the research, respectively.

3.2 Research philosophy

According to Saunders et al. (2016), research philosophy refers to the development of knowledge and the nature of the knowledge. The research philosophy that researchers adopt contains important assumptions about the way in which they view the world. These assumptions will underpin their research strategy and the methods they choose as part of that strategy. So, it is necessary to understand philosophical issues, since this understanding can assist in guiding researchers about the kind and form of data to be collected, as well as the appropriate approach to address the research problems. In agreement with this are Hair et al. (2018) when mentioning that in order to ensure satisfactory outcomes, researchers should thoroughly understand certain philosophical issues before conducting their research. The main research philosophies identified by Saunders et al. (2016) that typically apply to the business and management research are: positivism, interpretivism and realism.

According to Hair et al. (2018), positivism is the approach of application of the natural sciences to the research of social reality. This approach emphasizes the use of organized methods combining the deductive logic of existing theory with precise empirical observations, in order to formulate and confirm hypotheses. In that sense, this research adopted the positivism approach.

3.3 Research approach

There are two research approaches pointed by Saunders et al. (2016): deductive and inductive. Choosing the type of approach to use depends on the type of research to be done. According Saunders et al. (2016), the deductive approach involves testing and proving the theory developed. In contrast, the inductive approach is used for more exploratory researches, namely, involves observations and theories are proposed in the end of the research process. So, in the light of the above-mentioned philosophy, the researcher adopted a deductive approach to prove or disapprove the PMO conceptualization suggested, namely, testing the PMO conceptualization by analyzing the data collected from questionnaires and interviews developed.

3.4 Research strategy

The main purpose of the research strategy is to allow researchers to answer research question in order to achieve their research objectives. According Saunders et al. (2016), there are seven research strategies:

- Experiment: the experiment strategy consists of a strategy linked to natural sciences, although it features strongly in much social science research, particularly psychology;
- Survey: the survey strategy is a very common strategy in business and management research and is often associated with the inductive approach;
- Case study: the case study strategy allows the development of detailed and intensive knowledge about a case, and the data can be collected through several techniques such as interviews, observations and documentary analysis. So, as mentioned above, this strategy is the opposite of the experiment strategy;
- Action research: the action research strategy is more oriented to solving organizational problems, such as changes within an organization;
- Grounded theory: the grounded theory strategy consists of a strategy in which theory is based in data developed by various observations. So, it is used in an inductive approach;
- Ethnography: the ethnography strategy vigorously uses the inductive approach. It is considered a naturalistic strategy, because the researcher works with the subjects of the research, within the same context, and;

- Archival research: the archival research strategy uses administrative documents and records as source data rather than data resulting from the ongoing research process.

3.4.1 Survey strategy

The main strategy adopted in this research was the survey strategy. As the researcher mentioned above, and according Saunders et al. (2016), this strategy is a common strategy in business and management research and is frequently used to answer direct questions such as who, what, where, how much and how many. The survey strategy allows the researchers to collect quantitative data which they can analyze quantitatively using descriptive and inferential statistics. The use of this strategy should give more control over the research process and when sampling is used, it is possible to generate findings that are representative of the whole population at a lower cost than collecting the data for the whole population. Along with the surveys, there are other data collection techniques that belong to the survey strategy, such as observation and structured interviews.

3.4.2 Case study strategy

Although, and as was mentioned above, the main strategy for this research was the survey strategy, but the use of the case study strategy was also considered in this research.

The case study is one of the most commonly used research strategies when researchers intend to follow a qualitative approach (Yin, 2014); and is increasingly being used for building theories (Eisenhardt & Graebner, 2007). Using the case study strategy, on the one hand, the researchers focus on particular phenomena and discover crucial knowledge (Saunders et al., 2016) to provide guidance on how to implement and evaluate PM practice and its integration in organizations; and it is possible to demonstrate in practice the usefulness of the F&R identified for the purpose of PMO structure in particular in URC context.

In order to pursuit the main objectives of this research, RO_1 and RO_2, properly identified in section 1.4, it is essential to understand the case study context. As such, to identify the main F&R for the purpose of PMO structure in URC context this research takes into account the contingency theory (Van de Ven & Drazin, 1985). Contingency theory is being applied in the PM area over the last decades (Sauser, Reilly, & Shenhar, 2009). The contingency approach in PM investigates the extent of fit or misfit between project characteristics and the PM approach adopted (Hanisch & Wald, 2012; Sauser et al., 2009). Engwall

(2003) emphasizes the importance of a contingency approach and defends that projects are open systems dependent on history and organizational context.

Therefore, although the conceptualization proposed through the literature review in this research aims to be generic on the organizational context, i.e., applicable in any organization, the conceptualization proposed takes into account the organizational context, in this case a URC, to identify the relevance of each F&R for their own development. For example, URCs differ from other research centers in the way they are mostly funded, while others secure financing through corporate contracts; therefore the URC might certainly attach great importance to the functions related to the preparation and development of funding applications, while in others research centers, as their research is not funded, these application preparation and development functions are not as important.

The use of this strategy was explained by the fact that the researcher aimed to validate the application of the results obtained through the survey strategy in a particular case study.

In short, the researcher sought to validate the application of the proposal resulting from the survey strategy using the University of Minho case study. The case study consisted of the identification by the University of Minho's researchers of the most and least useful functions identified in the conceptualization proposed by the survey strategy, taking into consideration the context in which these researchers are inserted (University of Minho context).

3.5 Time horizons

Time horizons are needed for the research design independent of the research methodology used. There are only two types of time horizons: cross-sectional and longitudinal studies. The first are limited to a specific time frame and represent a snapshot of a particular event. In contrast to cross-sectional studies, longitudinal studies are developed over an extended period of time, and Saunders et al. (2016) point that the main strengths of this type of research is that it has capacity of study change and development. But, partly because of the time and costs involved, the longitudinal studies are relatively little used in business and management research. Once this research was limited to a specific time frame and to improve the reliability of the results, the cross-sectional time horizon was used.

3.6 Data collection methods

This research was conducted in two phases. A theoretically based model of PMO to support URC was proposed as the hinge between the phases. First, the initial conceptualization of PMO structures to support URC was proposed through secondary data gathered by literature review. Then, an online questionnaire was carried out to validate the proposed initial conceptualization. This primary data obtained from the questionnaire was analyzed and a final conceptualization of PMO structures to support URC was proposed. Finally, a case study was carried out by conducting interviews with the purpose to validate the main F&R identified for the purpose of PMO structure in URC context – the University of Minho context.

The major data collection methods that were used in this research were questionnaires and interviews. This section discusses the data collection methods used in this research.

3.6.1 Questionnaire method

The questionnaire consists of a technique directed to a large sample, in which several people answer the same set of questions with a certain order, that will allow the researchers to answer their research questions (Saunders et al., 2016). The questionnaire was developed by an online survey software tool named *Limesurvey*[3] and disseminated online through the e-mail contacts of researchers collected. The Appendix I – Questionnaire Form shows the questionnaire form used for this research. The analysis of the data collected through the questionnaire's dissemination served to support the designing and structuring of the interviews conducted.

3.6.2 Interviews method

This research used structured interviews. According Saunders et al. (2016), structured interviews are highly formalized interviews that use standardized questions for each research participant. Structured interviews do not give flexibility and freedom to respondents, and the researcher knows for sure how the interviews begins and ends. This type of interviewing is used to collect quantifiable data. The structured interviews were designed and developed taking into consideration the following aspects. The researcher provides some preliminary explanations about the context of the interview. The researcher should be able to avoid influencing the answer of the respondents. The researcher should guarantee that individual

[3] https://www.limesurvey.org

information or information previously obtained from one interview will not be disclosed and inform that any reproduction of responses will require prior authorization. Finally, the researcher needs to understand that it is important to show confidence and knowledge about the research subject, both in scientific and practical terms, and the researcher should avoid the use of academic language which could be understood by practitioners as a lack of knowledge about the real world.

Regarding the advantages and disadvantages of the interviewing data collection process, the researcher decided to tape notes and to tape record the interviews, in order to revisit again the interview data as often as necessary. The Appendix II – Interview Documentation shows in more detail the protocol and process used to conduct the interviews. Through the analysis of data collected from both questionnaires and interviews all research questions were answered and a final conceptualization of a PMO structure to support URC was conceived.

3.6.3 Summarized methods of data collection

Table 3 summarizes the data collection methods used in this research. The first column shows the method used. The second column shows the purpose. And the last two columns show the advantages and disadvantages of each method used.

Table 3 – Summary of data collection methods

Method	Purpose	Advantages	Disadvantages
Questionnaires	Used to get information from a large sample about the subject	Inexpensive method	Difficult to obtain sample contacts and guarantee of high response rates
Interviews	Used to get a depth information such as someone's impression and experience about the subject	Get depth information	Can be difficult and time consuming to analyze

Table 4 summarizes the data collection approach used. The table has the purpose of showing how the objectives are linked with all the other research processes, namely, data collection methods and expected outcomes. The first column in Table 4 presents the research aim and research objectives. The second column shows the data required in order to achieve the identified objectives. The third column illustrates the source of data, while the fourth and fifth columns present the data collection method and data analysis method and tools, respectively. The last column shows the expected outcomes.

Table 4 – Data collection approach

Research aim (RA) and research objectives (RO)	Data required	Source of data	Data collection method	Data analysis method and tools	Expected outcome
RO_1: To identify the main F&R associated with a PMO structure in URC contexts.	F&R underpinning a PMO structure	Documents	Documentary analysis	Content analysis and SPSS software tool	List of F&R associated to a PMO structure
		Researchers at world universities	Questionnaires		
RO_2: To validate the main functions and responsibilities (F&R) identified for a PMO structure in a specific URC context.	Determinant factors for suitability for purpose	Researchers from University of Minho	Interviews	Content analysis	List of the main F&R suitability for the purpose of PMO structure in a specific URC context
RA: To develop a conceptualization of a PMO structure to support URC.	Results from all above findings				

3.7 Research reliability and validity

According Saunders et al. (2016), in order to reduce the possibility of research going wrong, it is necessary to pay attention to two particular emphases on research design: reliability and validity.

Reliability refers to the consistency of the results produced through the various data collection methods used in the research. Validity is related to the appropriateness of the results to what they really appear to be. So, the question reliability asks is: *if another study were carried out research under the same circumstances would the results be the same?* And the question validity asks is: *what is being measured is really what it is intended to be measured?*

In this research, the reliability question was addressed through the use of methods such as questionnaires and interviews. These methods will result in more valid conclusions. On the other side, the validity question was addressed by comparing the findings to other researches. It should also be noted that, in this research, the selection of the sample for both the questionnaires and the interviews was based on URC researchers to ensure that the results could at least be generalized in similar URC contexts.

3.8 Population and sample

In order to address the aim and objectives presented in section 1.4, this research collected data from several professionals who work and research in URC contexts, through a dissemination of a questionnaire and the conduction of interviews. By the nature of the methods used, the questionnaires were disseminated by a large and global sample, while the interviews were conducted in a small and specific sample.

3.8.1 Questionnaire population and sample

The studied population included PhD and non-PhD researchers from URC. The selection of the sample was made on the websites of URC of twenty universities: MIT – Massachusetts Institute of Technology, Stanford University, Harvard University, Northwestern University, University of Buffalo, University of Washington, University of Colorado Boulder, University of Wisconsin-Madison, University of Cambridge, Imperial College London, University of Oxford, Nottingham Trent University, ETH Zurich - Swiss Federal Institute of Technology, University of Limerick, University of Bergen, University Alexandru Ioan Cuza, Nanyang Technological University, University of Minho, University of Coimbra and University of Porto.

Among all the chosen universities were selected 510 research centers and collected 18909 contacts to disseminate the questionnaire.

3.8.2 Interview population and sample

The identification of the potential researchers to participate on the structured interviews phase was based on following criteria:

1. Researchers at University of Minho;
2. Researchers belonging to research centers;
3. Researchers with proven experience in research projects.

Table 5 list the twenty-four researchers identified as potential to participate in the structured interviews phase, and that the researcher tried to gain access. Table 5 also gives a brief description of each potential researcher by research area, research center at the University of Minho and researcher's role in the research center.

Table 5 – Description of the potential University of Minho's researchers

Research center	Research area	Role
ALGORITMI Research Center	Operational Research and Discrete Event Simulation	Researcher with PhD Member of the IEM R&D Line Member of the SLOTS R&D Group
ALGORITMI Research Center	Embedded Systems, Instrumentation Systems and Microelectric-mechanical systems	Researcher with PhD Assistant Director of the ALGORITMI Research Centre Member of the IE R&D Line Member of the ESRG R&D Group
ALGORITMI Research Center	Computer Science	Researcher with PhD Member of the CCPM R&D Line Member of the EngageLab R&D Group
ALGORITMI Research Center	Modelation and Simulation of Engineering Systems	Researcher with PhD Member of the IEM R&D Line Member of the SLOTS R&D Group
ALGORITMI Research Center	Economics of Engineering Systems and Management	Researcher with PhD Member of the IEM R&D Line Member of the EMES R&D Group Coordinator of the IEM R&D Line
ALGORITMI Research Center	Logistics and Supply Chain Management	Researcher with PhD Assistant Director of the ALGORITMI Research Centre

Research center	Research area	Role
		Member of the IEM R&D Line Member of the SLOTS R&D Group Leader of the SLOTS R&D Group
ALGORITMI Research Center	Business Intelligence and Analytics	Researcher with PhD Member of the IST R&D Line Member of the SEMAG R&D Group Leader of the SEMAG R&D Group
ALGORITMI Research Center	Ergonomics and Human Factors	Researcher with PhD Member of the IEM R&D Line Member of the EHF R&D Group
ALGORITMI Research Center	Engineering Economics	Researcher with PhD Member of the IEM R&D Line Member of the SLOTS R&D Group
Center for Computer Graphics, CCG	Project Management and Software development processes	IT EPMQ Development Coordinator
Center for Computer Graphics, CCG	Industrial engineering and management	Program Manager
Centre for Mechanical and Materials Technology, CT2M	Mechanical, metallurgical and biological characterization	Researcher with PhD
Centre for Mechanical and Materials Technology, CT2M	Energy Engineering and Energy Conversion	Researcher with PhD Director of the CT2M
Centre for Mechanical and Materials Technology, CT2M	Mechanical properties of materials	Researcher with PhD
Centre of Physics of the University of Minho and Porto, CF-UM-UP	Atomic and Molecular Physics	Researcher with PhD
Communication and Society Research Centre, CECS	Communication Science	Researcher with PhD
DONE Lab - Advanced Manufacturing of Products and Tools	User-Centered Design and Additive Manufacturing technology	Researcher with PhD Co-Founder & COO
Institute of Polymers and Composites, IPC	Polymeric materials and nanocomposites	Researcher with PhD
Institute of Polymers and Composites, IPC	Rapid Prototyping and Manufacturing techniques	Researcher with PhD
Institute of Polymers and Composites, IPC	Surface and interfacial modification of carbons nanomaterials	Researcher with PhD
Institute of Polymers and Composites, IPC	Degradable and biodegradable polymeric materials and nanocomposites	Researcher with PhD

Research center	Research area	Role
Institute of Polymers and Composites, IPC	Mechanical and materials engineering	Researcher with PhD
Institute of Polymers and Composites, IPC	Advanced Polymer Systems	Researcher with PhD Director of the IPC
Research Group on Quality and Organizational Excellence, RG-QOE	Quality and Organizational Excellence	Researcher with PhD Coordinator

The researchers selected for the structured interviews were members involved in projects environment, in different levels of the organizational hierarchy. It is also important highlighting that for structured interviews, team members were involved, since they are active participants in projects (Milosevic & Srivannaboon, 2006; Shi, 2011).

3.9 Research ethics

Research ethics means ensuring the design of the research is methodology sound and morally defensible to all those involved (Saunders et al., 2016). So, ethics is something that must be taken into consideration during the research process. In this research, both questionnaire and interview respondents were informed of the aim, purpose and intent of this research, and their confidentiality and privacy were guaranteed. Also, in the case of the questionnaires, all the questions presented a response field for no opinion option, and, in the case of the interview, all respondents were informed that they would have the option to withdraw at any time and that this option would be respected in its entirety by eliminating all the information collected.

3.10 Research limitations

One of the inherent limitations of any research of this type is related to the research findings from the selected population sample. The findings can be generalized only to the population from which that sample was taken. This limitation is not particular to the methodology used. Thus, a larger and more representative sample of the population would increase the quality of this research.

Despite the limitations, this research has valuable contributions in extending the literature in the PMO context.

4. FINDINGS

4.1 Introduction

This chapter presents an analysis of data and also presents a discussion of the findings arising from the questionnaire phase. The chapter is divided into four sections. As can be verified below, this section presents the questionnaire's structure adopted, including the explanation of the reformulation of the F&R of the conceptualization proposed in section 2.5 for the URC context. The next section presents data analysis of the collected data, both descriptive and reliability analysis. The following section presents a summary of the results. Then, the comparison of results obtained between this research and the Ferreira's research (Ferreira, 2016; Ferreira, Tereso, & Fernandes, 2016) is presented in the last section.

As mentioned in section 1.4, and since the data obtained through Ferreira's research (2016) takes into consideration only the context of Portugal, Ferreira's research data will be grouped and analyzed together with the data that will be obtained by this dissemination in an international context. Therefore, in Table 6, it is possible to verify the main indicators related to the dissemination of the questionnaire.

Table 6 – General questionnaire dissemination indicators

	Ferreira's research (2016)	This research
Population sample	2856 researchers	18909 researchers
Response rate	8.5%	1.4%
1st stage of dissemination	July 2016	September 2017
2nd stage of dissemination	September 2016	December 2017
3rd stage of dissemination	-	February 2018

4.2 Questionnaire structure

For the questionnaire phase, the same questionnaire's structure used by Ferreira (2016) in her research was adopted, since the idea is to expand the research to an international context and, in fact, the literature review did not indicate any changes to be made. For that, the questionnaire was translated from Portuguese into an English language version.

Appendix I – Questionnaire Form shows the questionnaire's structure that was disseminated. In short, the questionnaire's structure was designed as a survey tool to gather the required data to better understand what the main functions that a PMO should have to support a URC (centers, institutes, labs

and departments). To that end, the questionnaire was divided in three groups: A, B and C. The group A was related to the URC and respondents' profiles (questions 1 to 8). In question 1 it was asked which type of research center the respondent belongs to. In question 2 it was asked the area of research of the center to which the respondent belongs. Question 3 was related to the role the respondent plays at the research center. In question 4 it was asked if the respondent's research center had a PMO or a similar structure. Question 5 was related to the classification of the PMO or similar structure of the respondent's research center, taking into account their functions, and only respondents who answered positively to question 4 could answer this question. Question 6 was related to the respondent's years of experience in research and PM. In questions 7 and 8, the respondent's age and gender were asked, respectively.

The group B was related with the utility of F&R performed in a PMO in order to improve the performance of R&D projects of the URC (questions 9 to 12). From questions 9 to 11 was asked the utility of the functions performed by a *Basic*, *Intermediate* and *Advanced PMO*, respectively, for improving the performance of R&D projects developed at respondent's research center. So, question 9 was related to the utility of functions in *Basic PMO*; question 10 was related to the utility of functions in *Intermediate PMO*; and question 11 was related to the utility of functions in *Advanced PMO*.

For that, as explained in Ferreira's research, it was necessary to adapt and reformulate the F&R presented in the proposed PMO conceptualization in section 2.5 to the context of URC. So, taking into account the fact that the functions of the literature can be very vague and very imprecise for those who do not have deep knowledge in PM, all the presented functions in Table 2 have been redesigned with the sole objective of clarifying their real function for the researchers who will respond to the questionnaire, as explained in section 3.6.

In this way, Tables 7, 8 and 9, present the process of adaptation and reformulation of the F&R presented in Table 2 for the context of URC. Table 7 is related to the *Basic PMO*, Table 8 is related to the *Basic PMO*, and Table 9 is related to the *Advanced PMO*.

Table 7 – Basic PMO F&R presented in the questionnaire

PMO Type	Nº	PMO F&R	PMO F&R for URC context
Basic PMO	FR1	Knowledge management: • Knowledge transfer • Increase knowledge about previous projects • Develop and manage files with project information • Lessons learned repository	Develop and manage repositories with past R&D project's information (knowledge management)
	FR2	Capture and disseminate good practices in project management	Ensure mentoring and coaching on the use of good project management practices by the principal investigator and her/his team
	FR3	Provide well-trained project managers and teams (through training, workshops and seminars)	Develop project management competences through training, workshops and seminars
	FR4	Promote social and informal interaction	Promote social interaction, stimulating research communities/groups in order to strengthen the bonds of trust between the members of the research center
			Ensure the cohesion of the team through a clear definition of the R&D projects' objectives, as well as the research center's objectives

Table 8 – Intermediate PMO F&R presented in the questionnaire

PMO Type	Nº	PMO F&R	PMO F&R for URC context
Intermediate PMO	FR5	Develop methodologies (standards, procedures and tools)	Characterize the different types of R&D projects currently at the research center (e.g., collaborative university-industry R&D projects)
			Develop and implement project management methodologies adjusted to each R&D project type
	FR6	Build a knowledge platform: • Ensure that projects consult the lessons learned • Post-project evaluation services	Create a platform that provides the relevant information of all past and ongoing R&D projects
			Provide, through a platform, updated information about conferences in the different research areas, as well as potential partners for research
			Implement and manage a lessons learned database so they can be incorporated in new R&D projects
	FR7	Provide periodic advice and guidance	Carry out specific project management tasks to support the principal investigator (e.g., project risk management, conduction of regular progress meetings with the R&D project team)
	FR8	Monitor and control project performance	Provide the principal investigator with a periodic report on the current state of the R&D project, particularly in terms of scope, time and cost (e.g. project cockpit chart)
	FR9	Risk management (identify risks and main problems)	Implement and manage a risk database associated with different types of R&D projects
	FR10	Support projects (support the decision-making process)	Provide software tools to support project management
	FR11	Supervision within the organization (monitor, summarize and report on project progress)	Conduct post-project reviews to ensure the exploitation of the R&D project's results (e.g., verify if the developed products have become commercialized products)
			Support the development of technical and financial reports to submit to the funding entity

Table 9 – Advanced PMO F&R presented in the questionnaire

PMO Type	Nº	PMO F&R	PMO F&R for URC context
Advanced PMO	FR12	Strategic management: • Ensure that the accepted projects are aligned with the organizational strategy • Align the needs of the project with those of the organization	Participate in the strategic planning of the research center, for the PMO to ensure the alignment of R&D projects with the research center strategy
	FR13	Evaluation, analysis and projects selection (provide interpretative assessments)	Identify, select and prioritize the new ideas for R&D projects
	FR14	Control and quality assurance	Ensure the quality of the different R&D projects' management, through dashboards and audits
	FR15	Project financial management: • Monitor projects in terms of budget and time • Provide administrative support to projects	Manage resource allocation between R&D project (resources capacity management)
			Seek funding for the development of R&D projects: networking and lobbying
	FR16	Close monitor and control of projects	Conduct follow-up meetings with each R&D project team to ensure the management and project status update of the R&D projects at the research center
	FR17	Human resource management: • Balancing skills • Ensure team cohesion with the project manager	Manage the allocation of human resources to research, in particular identifying areas lacking or with excess human resources, i.e., balancing the research capacities
	FR18	Project portfolio management (PPM)	Monitor and control the performance of R&D projects in order to report the status of the R&D projects portfolio to the research center's board
			Manage the exploitation of the results of each R&D project (e.g., knowledge and technology transfer, namely through university-industry interface units)

As can be verified in Table 10, the proposed conceptualization that will be the basis for the development of the rest of this research is composed of three types of PMO – *Basic PMO, Intermediate PMO and Advanced PMO* – and, in all, have twenty-five associated F&R (V1 to V25).

In a nutshell, both the type of PMO and the functions assigned to each type evolve according to the degree of complexity and involvement that the PMO structure is intended to have within the URC. For instance,

the *Basic PMO* and its associated functions have less strategic capacity when compared to the *Intermediate PMO*. And, in turn, the same is true between *Intermediate PMO* and *Advanced PMO*.

Table 10 – Initial conceptualization of PMO structure

PMO type	Survey/ Item	PMO F&R	Reference to Table 2
Basic PMO	V1	Develop and manage repositories with past R&D project's information (knowledge management)	FR1
	V2	Ensure mentoring and coaching on the use of good project management practices by the principal investigator and her/his team	FR2
	V3	Develop project management competences through training, workshops and seminars	FR3
	V4	Promote social interaction, stimulating research communities/groups in order to strengthen the bonds of trust between the members of the research center	FR4
	V5	Ensure the cohesion of the team through a clear definition of the R&D projects' objectives, as well as the research center's objectives	FR4
Intermediate PMO	V6	Characterize the different types of R&D projects currently at the research center (e.g., collaborative university-industry R&D projects)	FR5
	V7	Develop and implement project management methodologies adjusted to each R&D project type	FR5
	V8	Create a platform that provides the relevant information of all past and ongoing R&D projects	FR6
	V9	Provide, through a platform, updated information about conferences in the different research areas, as well as potential partners for research	FR6
	V10	Implement and manage a lessons learned database so they can be incorporated in new R&D projects	FR6
	V11	Carry out specific project management tasks to support the principal investigator (e.g., project risk management, conduction of regular progress meetings with the R&D project team)	FR7
	V12	Provide the principal investigator with a periodic report on the current state of the R&D project, particularly in terms of scope, time and cost (e.g. project cockpit chart)	FR8
	V13	Implement and manage a risk database associated with different types of R&D projects	FR9
	V14	Provide software tools to support project management	FR10
	V15	Conduct post-project reviews to ensure the exploitation of the R&D project's results (e.g., verify if the developed products have become commercialized products)	FR11
	V16	Support the development of technical and financial reports to submit to the funding entity	FR11
Advanced	V17	Participate in the strategic planning of the research center, for the PMO to ensure the alignment of R&D projects with the research center strategy	FR12

PMO type	Survey/ Item	PMO F&R	Reference to Table 2
	V18	Identify, select and prioritize the new ideas for R&D projects	FR13
	V19	Ensure the quality of the different R&D projects' management, through dashboards and audits	FR14
	V20	Manage resource allocation between R&D project (resources capacity management)	FR15
	V21	Seek funding for the development of R&D projects: networking and lobbying	FR15
	V22	Conduct follow-up meetings with each R&D project team to ensure the management and project status update of the R&D projects at the research center	FR16
	V23	Manage the allocation of human resources to research, in particular identifying areas lacking or with excess human resources, i.e., balancing the research capacities	FR17
	V24	Monitor and control the performance of R&D projects in order to report the status of the R&D projects portfolio to the research center's board	FR18
	V25	Manage the exploitation of the results of each R&D project (e.g., knowledge and technology transfer, namely through university-industry interface units)	FR18

Question 12, also concerning to group B, was an open-ended question and was related to the identification of other functions not identified in the questionnaire but which respondents considered relevant to include in the PMO structure in order to improve PM in URC context.

The last group, group C, was related to the respondent's opinion in concerning the implementation of the PMO structure (question 13 to 14). In question 13 was asked if the respondent would be available to cooperate in specific activities if a PMO was created at respondent's research center. In question 14 was asked if the respondent believed as useful the establishment of a PMO at respondent's research center.

4.3 Questionnaire data analysis

Since the intention is to validate the initial conceptualization of the PMO structure for URC, the researcher divided the data analysis into two parts. In the first part, section 4.3.1, the researcher presents the descriptive analysis of the data collected. For purpose of clarity and consistency, the descriptive analysis is not presented in the ascending order of the questionnaire questions. Firstly, the data collected from groups A and C are analyzed and only then the descriptive analysis of group B is presented. In the second part, section 4.3.2, it presents the reliability analysis of data collected in group B. It is through the

reliability analysis that it will be possible to validate the initial conceptualization of the PMO structures in the URC context.

4.3.1 Descriptive analysis

A total of the 505 answers were obtained, among which only 370 were valid answers entered in the database. This difference between the answers obtained and the answers considered valid is due to the fact that: (1) all incomplete answers were excluded, and (2) even for complete questionnaires not all were considered valid. It was necessary to analyze each complete questionnaire received in order to avoid those answers that were only performed to complete the questionnaire and that not making significant contribution to the research, specifically those answers in which there is a constant linearity of answer to all questions of the questionnaire. The following procedure was considered to assess the valid answers of all the complete answers received. The linearity of the answers can only be verified in group B of the questionnaire, especially in questions 9 to 11, since they are the ones related to the usefulness of the F&R and, as such, they are the ones that present the largest number of answer options. Consequently, all answers that presented a linearity in at least two of questions 9 to 11 were considered invalid. This analysis resulted in the verification of 135 invalid answers.

This high number of exclusions might be related to the lack of knowledge of people involved in research institutions on the F&Rs of PMOs and therefore they understand that the F&Rs are all equally useful.

Considering the valid answers, it was possible to verify that the male gender had the highest participation: 39% of the female gender and 61% of the male gender.

As can be seen in Figure 3, regarding the age group (question 7), 77% of the respondents were between 30 and 59 years old, 6% were less than 30 years old, 11% were between 60 and 69 years old and 6% were more than 69 years old.

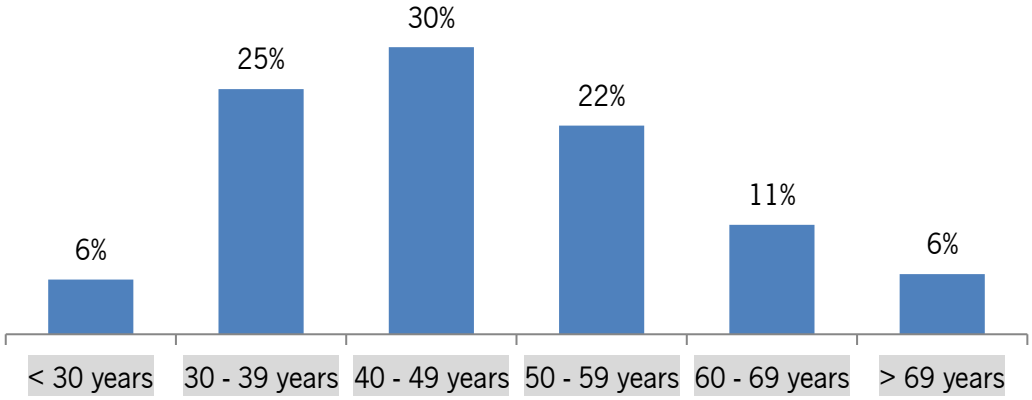

Figure 3 – Respondents' age group

Regarding the distribution of type of URC (question 1), the *'University departments'* represent more than half of the sample, 80%. Thereafter, the *'Centers'* appear with 9%, *'Institutes'* with 6% and the *'Labs'* with only 1%. 3% of the respondents indicated the *'Other'* option. Figure 4 illustrates the results of this distribution.

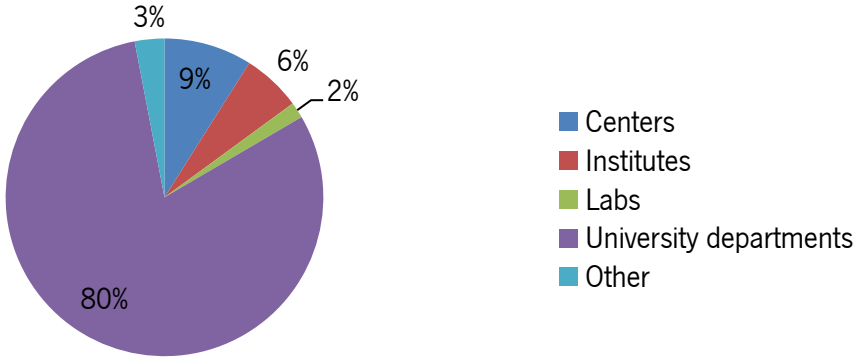

Figure 4 – Respondents' URC typology

Concerning the respondents' scientific areas of research projects (question 2), the most represented areas were *'Exact Sciences and Engineering'* and *'Social Sciences and Humanities'* with, respectively, 39% and 32%. Then, *'Life and Health Sciences'* appear with 14% and *'Natural and Environment Sciences'* with 7%. 8% of the respondents indicated the other option.

The respondents were asked to indicate the roles that they perform in their URC (question 3). The sample is distributed according to Table 11. The responses revealed that 10% were *'Director'*, 3% were *'Board Member'*, 10% were *'Line/Research Group Coordinator'*, 29% were *'Senior Research Fellow'*, 21% were

'Research Fellow', 7% were *'Research Assistant'*, 2% were *'Administrative'* and 18% indicated the *'Other'* option.

Table 11 – Respondents' roles performed at the URC

Respondents' roles performed at the URC	%
Director	10
Board Member	3
Line/Research Group Coordinator	10
Senior Research Fellow	29
Research Fellow	21
Research Assistant	7
Administrative	2
Other	18

The respondents were also asked if they had any work experience in PM roles, namely, *'Director or Line/Research Group Coordinator'*; *'Manager/Coordinator of R&D Project'*; and *'Member of R&D Project Team'* (question 6). In general, the role with the most experience, throughout the age group, was 'Member of R&D Project Team' with the average being in the class of 7 and 10 years and the median in the class of more than 10 years of experience. Followed by *'Manager/Coordinator of R&D Project'* with the average and median being in the class of 4 and 6 years of experience. And, lastly, *'Director or Line/Research Group Coordinator'* with the average being in the class of 1 and 3 years and the median in the class of less than 1 year of experience. These results represent the reality in the sense that there are more people involved in the role *'Member of R&D Project Team'* than *'Manager/Coordinator of R&D Project'* or *'Director or Line/Research Group Coordinator'* and, consequently, there are more people involved in the role *'Manager/Coordinator of R&D Project'* than *'Director or Line/Research Group Coordinator'*.

Table 12 – Respondents' experience in PM roles

Role(s) at the research center	None %	< 1 year %	1 – 3 years %	4 – 6 years %	7 – 10 years %	> 10 years %
Director or Line/Research Group Coordinator	56	4	12	7	6	15
Manager/Coordinator of R&D Project	39	3	13	13	9	23
Member of R&D Project Team	9	3	12	13	21	42
Other	83	0	1	2	2	12

As shown in Table 12, the role that the responses indicated as begin the one where they have the most experience were *'Member of R&D Project Team'* with 42% of the responses indicated that they have more than 10 years of experience, 21% were between 7 and 10 years, 13% were between 4 and 6 years, 12% were between 1 and 3 years, 9% were without experience, and, lastly, 3% were less than 1 year. Then comes the role *'Manager/Coordinator of R&D Project'* with 23% of the responses indicated that they have more than 10 years of experience, 13%, simultaneous, were between 1 and 3 years and 4 and 6 years, 9% were between 7 and 10 years, and 3% were less than 1 year. In this role, 39% respondents indicated that they do not have experience. Finally, the role *'Director or Line/Research Group Coordinator'* appears with 15% of the responses indicated that they have more than 10 years of experience, 12% were between 1 and 3 years, 7% were between 4 and 6 years, 6% were between 7 and 10 years, 4% were less than 1 year, and, lastly, 56% of the respondents indicated that they do not experience.

The results of question 4 support the suspicious that their URC are not yet familiar with the concept of PMO and that PMO structures are not present in most URC. Only 37% of the respondents collaborate with URC that have a PMO, which means that 63% of the respondents do not have PMO structures in their URC.

In what concerns the types of PMOs that are implemented in the URC (question 5), of the respondents who responded that they had a PMO structure in their URC, 64% indicated that their PMOs perform support roles, while 26% perform control roles and 10% perform roles of direction. This shows that most of the PMO implemented in the URCs of the sample perform roles with little management and authority over the R&D projects, mostly performing only project support roles, with very little direct control over them. Table 13 shows these results.

Table 13 – PMO's classification

How would you classify the PMO at your URC concerning its functions?	%
Supportive – It operates as a service unit: it provides administrative and operational support to projects, performs specialized tasks and gives access to information and lessons learned. The degree of control over the projects is low	64
Controlling – It implements methodologies and standardized project management tools adapted to the organization, monitors compliance with the project management rules and accepted management functions under the projects that are in its domain. The degree of control over the projects is moderate	24
Directive – It manages projects directly and controls all research center's projects. The degree of control over the projects is high	10

The respondents were also asked, if a PMO was created at their URC, if they would be available to cooperate in activities, namely, *help create an information repository of past projects by completing a report/form for each R&D project*; *collaborate with the PMO staff in improving project management practices in your R&D projects*; and *conduct follow-up meetings with the PMO staff, to ensure the management and to update the status of your R&D projects* (question 13). In general, all activities presented their average and median in the *High* class. This indicates that the respondents were motivated to cooperate in the activities which means that the presence of PMO structures in URC is important to support the work developed by researchers.

Table 14 – Available of respondents to cooperate in activities

Question 13	None %	Very small %	Medium %	High %	Full %	No opinion %
Help create an information repository of past projects by completing a report/form for each R&D project	6	19	28	28	14	5
Collaborate with the PMO staff in improving project management practices in your R&D projects	3	12	30	35	15	5
Conduct follow-up meeting with the PMO staff, to ensure the management and to update the status of your R&D projects	4	11	29	36	14	6

As shown in Table 14, in the activity of *'Help create an information repository of past projects by completing a report/form for each R&D project'*, 28% of the respondents indicated, simultaneous, medium and high cooperation, then 19% indicated very small cooperation, 14% indicated full cooperation,

6% indicated no cooperation, and, lastly, 5% of the respondents have no opinion on the subject. In the activity of *'Collaborate with the PMO staff in improving project management practices in your R&D projects'*, 35% of the respondents indicated high cooperation, then 30% indicated medium cooperation, 15% indicated full cooperation, 12% indicated very small cooperation, 3% indicated no cooperation, and, lastly, 5% of the respondents have no opinion on the subject. Finally, in the activity *'Conduct follow-up meeting with the PMO staff, to ensure the management and to update the status of your R&D projects'*, 36% of the respondents indicated high cooperation, then 29% indicated medium cooperation, 14% indicated full cooperation, 11% indicated very small cooperation, 4% indicated no cooperation, and, lastly, 6% of the respondents have no opinion on the subject.

Most respondents, 81%, believe that the establishment of a PMO structure is or would be useful for their URC. With almost the same percentage, 10% of the respondents shown that there is no need to implement PMO structures and 9% have no opinion (question 14).

As explained above, the descriptive analysis of the data collected in group B is now presented.

For reasons of consistency, the analysis of the utility attributed to the functions of the *Basic PMO* is presented first, then the *Intermediate PMO* and *Advanced PMO* appear. Table 15, Table 16 and Table 17 summarize the information regarding the mean, median, mode and standard deviation of each of the *Basic PMO*, *Intermediate PMO* and *Advanced PMO*, respectively.

It is important to note that to calculate the values of means, medians, modes and standard deviations it was necessary to transform the utility scale used in the questionnaire to numerical values. The scale used was as follows: 1 – *'Very low'*; 2 – *'Low'*; 3 – *'Medium'*; 4 – *'High'*; and 5 – *'Very high'*.

The sample number of responses varies from function to function, due to responses given in the '*no opinion'* option, which have no assigned value. Table 15 summarizes respondents' preferences regarding the utility of the *Basic PMO* functions.

Table 15 – Statistical results of the Basic PMO

Item	PMO F&R	Mean	Median	Mode	Standard deviation
V1	Develop and manage repositories with past R&D project's information (knowledge management)	3.54	4	4	1.20
V2	Ensure mentoring and coaching on the use of good project management practices by the principal investigator and her/his team	3.53	4	4	1.35
V3	Develop project management competences through training, workshops and seminars	3.48	4	4	1.20
V4	Promote social interaction, stimulating research communities/groups in order to strengthen the bonds of trust between the members of the research center	3.41	4	4	1.31
V5	Ensure the cohesion of the team through a clear definition of the R&D projects' objectives, as well as the research center's objectives	3.41	4	4	1.41

The median value assumes the same value for all functions, 4, which means that in all functions at least 50% of the sample assigned values equal to or greater than utility 4. In this PMO, 2% of the total sample admitted having no opinion on each of the functions presented.

In function V1 the utility level with the highest number of responses was level 4 with 36% of the responses. Then levels 3 and 5, appear with, respectively, 25% and 21%. These values confirm the median value given, since 57% of the responses give this function a utility of 4 or 6. 82% of the responses are between utility levels 3 and 5. This function, in simultaneous with function V3, presents the smallest variation in responses compared to the mean value, presenting a standard deviation value of 1.20.

Function V2 has the highest number of responses at utility levels 4 and 5, simultaneous, with 28% of the responses. Then level 3 appears with 25% of the responses These values confirm the median value given, since 56% of the responses give this function a utility of 4 or 5. 81% of the responses are between utility levels 3 and 5. This function presents a standard deviation value of 1.35.

In function V3 the utility level with the highest number of responses was level 4 with 34% of the responses. Then levels 3 and 5, appear with, respectively, 31% and 19%. These values confirm the median value given, since 53% of the responses give this function a utility of 4 or 5. 84% of the responses are between utility levels 3 and 5. This function presents a standard deviation value of 1.20.

Function V4 has the highest number of responses at utility level 4 with 31% of the responses. Then levels 3 and 5 appear with, respectively, 28% and 21%. These values confirm the median value given, since

52% of the responses give this function a utility of 4 or 5. 80% of the responses are between utility levels 3 and 5. This function presents a standard deviation value of 1.31.

In function V5 the utility level with the highest number of responses was level 4 with 28% of the responses. Then levels 5 and 3, appear with, respectively, 25% and 24%. These values confirm the median value given, since 53% of the responses give this function a utility of 4 or 5. 77% of the responses are between utility levels 3 and 5. This function is the one with the highest variation in responses compared to the mean value, presenting a standard deviation value of 1.41.

It can be concluded that all functions of this PMO have high utility, since all of them have an average higher than 3.41 and in all functions 81% of the responses are in the 3 highest levels of utility.

As mentioned above, the next PMO to be evaluated for its functions is the *Intermediate PMO* (see Table 16). Overall, the functions of this PMO, compared to the *Basic PMO*, already require more knowledge about the context of PM. Perhaps this justifies the 2 percentage points increase in the responses without opinion (4%) when compared to the *Basic PMO* (2%). On the other hand, the results indicate that, in general, the respondents consider the functions of this PMO important since the average of the utilities presented in the *Intermediate PMO* was slightly higher than those presented in the *Basic PMO*, respectively, 3.54 and 3.47. Table 16 summarizes respondents' preferences regarding the utility of the *Intermediate PMO* functions.

Table 16 – Statistical results of the Intermediate PMO

Item	PMO F&R	Mean	Median	Mode	Standard deviation
V6	Characterize the different types of R&D projects currently at the research center (e.g., collaborative university-industry R&D projects)	3.26	3	3	1.16
V7	Develop and implement project management methodologies adjusted to each R&D project type	3.54	4	4	1.25
V8	Create a platform that provides the relevant information of all past and ongoing R&D projects	3.70	4	4	1.15
V9	Provide, through a platform, updated information about conferences in the different research areas, as well as potential partners for research	3.37	4	4	1.37
V10	Implement and manage a lessons learned database so they can be incorporated in new R&D projects	3.43	4	4	1.35
V11	Carry out specific project management tasks to support the principal investigator (e.g., project risk management,	3.79	4	5	1.33

Item	PMO F&R	Mean	Median	Mode	Standard deviation
	conduction of regular progress meetings with the R&D project team)				
V12	Provide the principal investigator with a periodic report on the current state of the R&D project, particularly in terms of scope, time and cost (e.g. project cockpit chart)	3.83	4	5	1.23
V13	Implement and manage a risk database associated with different types of R&D projects	3.01	3	3	1.34
V14	Provide software tools to support project management	3.49	4	4	1.27
V15	Conduct post-project reviews to ensure the exploitation of the R&D project's results (e.g., verify if the developed products have become commercialized products)	3.40	4	4	1.41
V16	Support the development of technical and financial reports to submit to the funding entity	4.17	4	5	1.02

Function V6 has the highest number of responses in utility level 3 with 37% of the responses. Then levels 4 and 5 appear with, respectively, 32% and 11%. These values confirm the median value given, since 80% of the responses give this function a utility greater than 3. This function presents a standard deviation value of 1.216.

In function V7 the utility level with the highest number of responses was level 4 with 34% of the responses. Then levels 5 and 3 appear with, respectively, 23% and 22%. These values confirm the median value given, since 57% of the responses give this function a utility of 4 or 5. 79% of the responses are between utility levels 3 and 5. This function presents a standard deviation value of 1.25.

In function V8 the utility level with the highest number of responses was level 4 with 35% of the responses. Then levels 5 and 3 appear with, respectively, 26% and 21%. These values confirm the median value given, since 61% of the responses give this function a utility of 4 or 5. 82% of the responses are between utility levels 3 and 5. This function presents a standard deviation value of 1.15.

Function V9 has the highest number of responses in utility 4 with 31% of the responses. Following levels 3 and 5 with, respectively, 22% and 21%. These values confirm the median value given, since 52% of the responses give this function a utility of 4 or 5. 74% of the responses are between utility levels 3 and 5. This function presents a standard deviation value of 1.37.

In function V10 the utility level with the highest number of responses was level 4 with 33% of the responses. Then levels 3 and 5 appear with, respectively, 24% and 21%. These values confirm the median

value given, since 54% of the responses give this function a utility of 4 or 5. 78% of the responses are between utility levels 3 and 5. This function presents a standard deviation value of 1.35.

Function V11 has the highest number of responses in utility 5 with 37% of the responses. Following levels 4 and 3 with, respectively, 27% and 17%. These values confirm the median value given, since 64% of the responses give this function a utility of 4 or 5. 81% of the responses are between utility levels 3 and 5. This function presents a standard deviation value of 1.35.

In function V12 the utility level with the highest number of responses was level 5 with 34% of the responses. Then levels 4 and 3 appear with, respectively, 32% and 17%. These values confirm the median value given, since 66% of the responses give this function a utility of 4 or 5. 83% of the responses are between utility levels 3 and 5. This function presents a standard deviation value of 1.23.

Of all the *Intermediate PMO* functions, the function V13 is the one with the lowest utility level: value of 3.01 for mean and value of 3 for median and mode. The utility level with the highest number of responses was level 3 with 31% of the responses. Following levels 4 and 2 with, respectively, with 26% and 14%. Level 5 appears with 11% of the responses. These values confirm the median value given, since 68% of the responses give this function a utility greater than 3. This function presents a standard deviation value of 1.34.

In function V14 the utility level with the highest number of responses was level 4 with 32% of the responses. Then levels 3 and 5 appear with, respectively, with 27% and 22%. These values confirm the median value given, since 54% of the responses give this function a utility of 4 or 5. 81% of the responses are between utility levels 3 and 5. This function presents a standard deviation value of 1.27.

Function V15 has the highest number of responses at utility level 3 with 29% of the responses. Then levels 3 and 5 appear with, respectively, 25% and 24%. These values confirm the median value given, since 53% of the responses give this function a utility of 4 or 5. 78% of the responses are between utility levels 3 and 5. This function is the one with the highest variation in responses compared to the mean value, presenting a standard deviation value of 1.41.

In function V16 the utility level with the highest number of responses was level 5 with 45% of the responses. Then levels 4 and 3, appear with, respectively, 29% and 13%. These values confirm the median value given, since 74% of the responses give this function a utility of 4 or 5. 87% of the responses are between utility levels 3 and 5. This function presents the smallest variation in responses compared to the mean value, presenting a standard deviation value of 1.02. Therefore, this function is the one with the highest utility. It has the highest mean value and lowest standard deviation.

Of the 3 PMO models to be analyzed, the *Advanced PMO* is where it is most difficult to perceive the value of the assigned functions because it is an exclusive PMO and where deep PM knowledge is required. This assumption justifies the fact that the standard deviation values are higher than in the *Basic and Intermediate PMOs*. In this case, the lowest and highest standard deviation values are, respectively, 1.31 and 1.41. In all, the average of standard deviation values of the *Basic*, *Intermediate* and *Advanced PMO* are, respectively, 1.29, 1.26 and 1.36. On the other hand, the average of the utilities presented in the *Advanced PMO* (3.33) was slightly lower than those presented in the *Basic* (3.47) *and Intermediate PMO* (3.54). Table 17 summarizes respondents' preferences regarding the utility of the *Advanced PMO* functions.

Table 17 – Statistical results of the Advanced PMO

Item	PMO F&R	Mean	Median	Mode	Standard deviation
V17	Participate in the strategic planning of the research center, for the PMO to ensure the alignment of R&D projects with the research center strategy	3.40	4	4	1.36
V18	Identify, select and prioritize the new ideas for R&D projects	3.11	3	4	1.40
V19	Ensure the quality of the different R&D projects' management, through dashboards and audits	3.12	3	4	1.39
V20	Manage resource allocation between R&D project (resources capacity management)	3.31	4	4	1.32
V21	Seek funding for the development of R&D projects: networking and lobbying	3.87	4	5	1.41
V22	Conduct follow-up meetings with each R&D project team to ensure the management and project status update of the R&D projects at the research center	3.27	4	4	1.31
V23	Manage the allocation of human resources to research, in particular identifying areas lacking or with excess human resources, i.e., balancing the research capacities	3.08	3	4	1.40
V24	Monitor and control the performance of R&D projects in order to report the status of the R&D projects portfolio to the research center's board	3.38	4	4	1.37
V25	Manage the exploitation of the results of each R&D project (e.g., knowledge and technology transfer, namely through university-industry interface units)	3.41	4	4	1.31

In function V17 the utility level with the highest number of responses was level 4 with 32% of the responses. Then levels 3 and 5 appear with, respectively, 25% and 21%. These values confirm the median

value given, since 53% of the responses give this function a utility of 4 or 5. 78% of the responses are between utility levels 3 and 5. This function presents a standard deviation value of 1.36.

Function V18 has the highest number of responses at utility level 4 with 32% of the responses. Then levels 3 and 5 appear with, respectively, 25% and 14%. These values confirm the median value given, since 57% of the responses give this function a utility of 3 and 4. 71% of the responses are between utility levels 3 and 5. This function presents a standard deviation value of 1.40.

In function V19 the utility level with the highest number of responses was level 4 with 31% of the responses. Then levels 3 and 5 appear with, respectively, 25% and 13%. These values confirm the median value given, since 56% of the responses give this function a utility of 3 and 4. 69% of the responses are between utility levels 3 and 5. This function presents a standard deviation value of 1.39.

Function V20 has the highest number of responses at utility level 4 with 35% of the responses. Then levels 3 and 5 appear with, respectively, 25% and 15%. These values confirm the median value given, since 50% of the responses give this function a utility of 4 and 5. 77% of the responses are between utility levels 3 and 5. This function presents a standard deviation value of 1.32.

In function V21 the utility level with the highest number of responses was level 5 with 41% of the responses. Then levels 4 and 3 appear with, respectively, 26% and 13%. These values confirm the median value given, since 67% of the responses give this function a utility of 4 and 5. 80% of the responses are between utility levels 3 and 5. Interestingly, this function, although it has high median and mode values, is the one with the highest standard deviation value, 1.41, and one of the highest response rate in the responses without opinion (7%). This demonstrates some imbalance in the answers given and respondents may not be sure of the utility of this function.

Function V22 has the highest number of responses at utility level 4 with 36% of the responses. Then levels 3 and 5 appear with, respectively, 27% and 14%. These values confirm the median value given, since 50% of the responses give this function a utility of 4 and 5. 77% of the responses are between utility levels 3 and 5. This function is the one with the lowest variation in responses compared to the mean value, presenting a standard deviation value of 1.31.

In function V23 the utility level with the highest number of responses was level 4 with 28% of the responses. Then levels 3 and 5 appear with, respectively, 27% and 14%. These values confirm the median value given, since 55% of the responses give this function a utility of 3 and 4. 69% of the responses are between utility levels 3 and 5. This function presents a standard deviation value of 1.40.

Function V24 has the highest number of responses at utility level 4 with 35% of the responses. Then levels 3 and 5 appear with, respectively, 24% and 19%. These values confirm the median value given, since 54% of the responses give this function a utility of 4 and 5. 78% of the responses are between utility levels 3 and 5. This function presents a standard deviation value of 1.37.

Finally, in function V25 the utility level with the highest number of responses was level 4 with 34% of the responses. Then levels 3 and 5 appear with, respectively, 25% and 19%. These values confirm the median value given, since 53% of the responses give this function a utility of 4 and 5. 78% of the responses are between utility levels 3 and 5. This function presents a standard deviation value of 1.31.

In a general way, it was possible to verify that all researchers consider that most F&R are important in supporting PM, since 78% of the responses correspond to the *medium*, *high* and *very high* utility levels. In particular, when the median values of the given responses were analyzed, it was verified that all F&R have responses at the *medium* and *high* utility levels. See Figure 5 and Figure 6 for more detail.

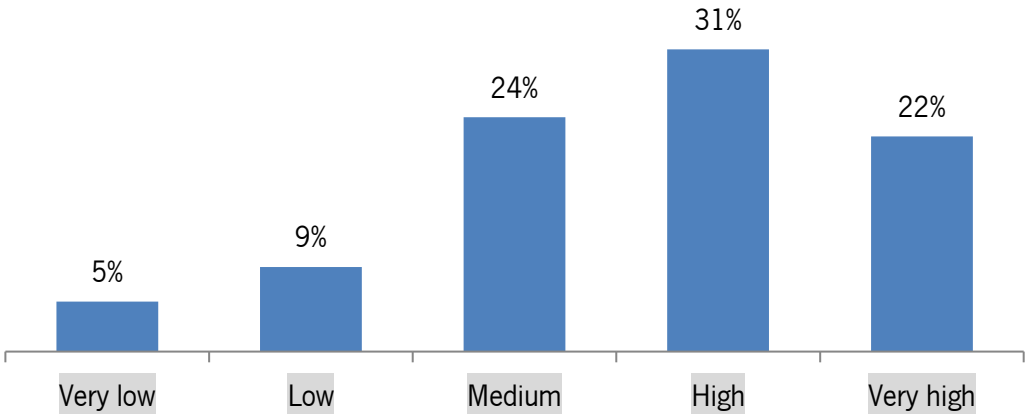

Figure 5 – Percentage of responses by utility level

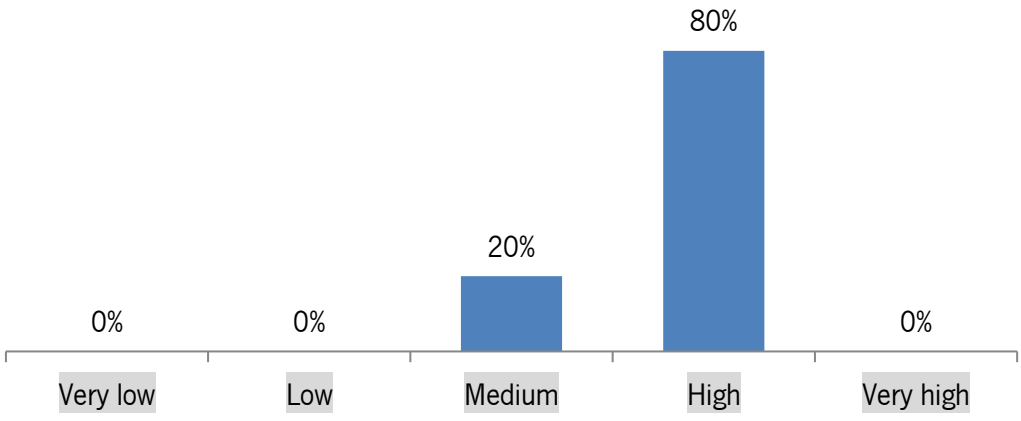

Figure 6 – Median values of utility levels obtained by the questionnaires

From all the F&R presented, as can be verified in Figure 7, the three least useful identified by the researchers were V19, V23 and V13, with, respectively, 20%, 19% and 18%. These values result from the analysis and aggregation of all the answers given with low utilities (respectively, *'None'* and *'Very low'* utility) plus the no opinion answers.

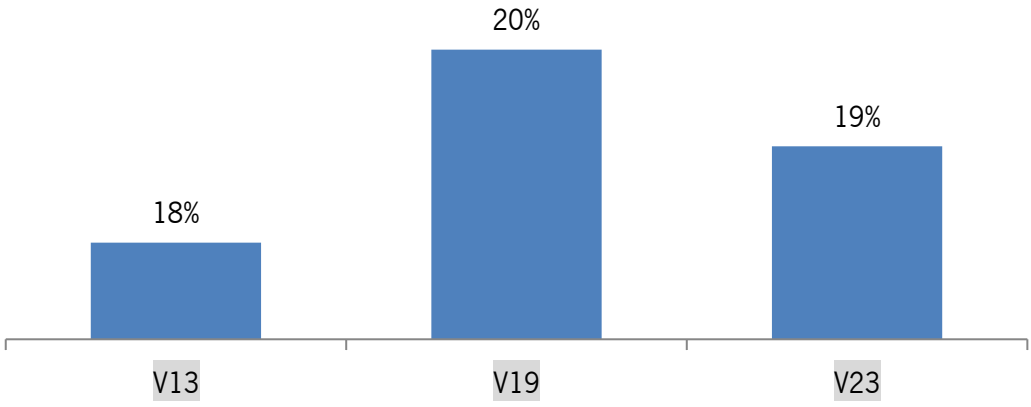

Figure 7 – Ranking of the least useful F&R obtained by the questionnaires

Table 18 shows in detail the percentage of the given responses by utility level in each F&R.

Table 18 – Percentage of responses by utility level in each F&R

Item	PMO F&R	None %	Very low %	Low %	Medium %	High %	Very high %	No opinion %
V1	Develop and manage repositories with past R&D project's information (knowledge management)	2	5	9	25	36	21	2
V2	Ensure mentoring and coaching on the use of good project management practices by the principal investigator and her/his team	4	6	7	25	28	28	2
V3	Develop project management competences through training, workshops and seminars	3	4	7	31	34	19	2
V4	Promote social interaction, stimulating research communities/groups in order to strengthen the bonds of trust between the members of the research center	4	6	8	28	31	21	2
V5	Ensure the cohesion of the team through a clear definition of the R&D projects' objectives, as well as the research center's objectives	7	3	11	24	28	25	2

Item	PMO F&R	None %	Very low %	Low %	Medium %	High %	Very high %	No opinion %
V6	Characterize the different types of R&D projects currently at the research center (e.g., collaborative university-industry R&D projects)	3	6	8	37	32	11	3
V7	Develop and implement project management methodologies adjusted to each R&D project type	3	4	11	22	34	23	3
V8	Create a platform that provides the relevant information of all past and ongoing R&D projects	2	2	10	21	35	26	4
V9	Provide, through a platform, updated information about conferences in the different research areas, as well as potential partners for research	4	8	11	22	31	21	3
V10	Implement and manage a lessons learned database so they can be incorporated in new R&D projects	5	5	8	24	33	21	4
V11	Carry out specific project management tasks to support the principal investigator (e.g., project risk management, conduction of regular progress meetings with the R&D project team)	3	3	7	17	27	37	6
V12	Provide the principal investigator with a periodic report on the current state of the R&D project, particularly in terms of scope, time and cost (e.g. project cockpit chart)	3	3	6	17	32	34	5
V13	Implement and manage a risk database associated with different types of R&D projects	6	7	14	31	26	11	5
V14	Provide software tools to support project management	4	3	9	27	32	22	3
V15	Conduct post-project reviews to ensure the exploitation of the R&D project's results (e.g., verify if the developed products have become commercialized products)	6	5	8	25	29	24	3
V16	Support the development of technical and financial reports to submit to the funding entity	1	2	4	13	29	45	6
V17	Participate in the strategic planning of the research center, for the PMO to ensure	6	4	8	25	32	21	4

Item	PMO F&R	None %	Very low %	Low %	Medium %	High %	Very high %	No opinion %
	the alignment of R&D projects with the research center strategy							
V18	Identify, select and prioritize the new ideas for R&D projects	7	7	12	25	32	14	3
V19	Ensure the quality of the different R&D projects' management, through dashboards and audits	6	8	11	25	31	13	6
V20	Manage resource allocation between R&D project (resources capacity management)	5	6	8	27	35	15	4
V21	Seek funding for the development of R&D projects: networking and lobbying	4	5	4	13	26	41	7
V22	Conduct follow-up meetings with each R&D project team to ensure the management and project status update of the R&D projects at the research center	6	5	10	27	36	14	2
V23	Manage the allocation of human resources to research, in particular identifying areas lacking or with excess human resources, i.e., balancing the research capacities	6	9	12	27	28	14	4
V24	Monitor and control the performance of R&D projects in order to report the status of the R&D projects portfolio to the research center's board	6	7	5	24	35	19	4
V25	Manage the exploitation of the results of each R&D project (e.g., knowledge and technology transfer, namely through university-industry interface units)	5	5	8	25	34	19	4

Regarding question 12, it was possible to verify the collection of 69 answers. However, after analyzing them, only 35 answers were considered useful and relevant for the research and therefore were considered valid. Table 19 presents these 35 valid answers. The answers considered not valid did not add pertinent information to the research. Many of the invalid answers (10 answers) indicated that *'the functions have been listed'* or *'the PMO functions are described very well'* or *'it seems that the important functions are already listed'*. Others (22 answers) pointed out that researchers do not have PMO at their research center and therefore find no other necessary functions. Others (2 answers) pointed out that a

PMO structure is not required at their research center, such as *'A PMO sounds like functionaries who neither do research nor teach. Such groups should be purged from scientific/engineering as adding to the bureaucratic cost burden and getting in the way of professors taking on the crucial responsibilities listed in this questionnaire'*.

Table 19 – Respondents' valid answers to question 12

ID	Respondents' valid answers	Reference to Table 10
A1	Develop writing skills	V3
	Create a network	V21
A2	Develop proposals for funding	**NEW**
	Search and select funding opportunities	V21
A3	Facilitate execution of the project by removing potential roadblocks (i.e.: facilitate intra and inter institutional communication, etc.)	V4
	Facilitate execution of the project by removing potential roadblocks (i.e.: access to core laboratories, putting in place contracts in an efficient and effective manner, organize meeting among investigators and their teams to discuss progress etc.)	V11
A4	Help PIs to identify, understand and adjust their grant applications according to available sources of funding	V20
	Create a portfolio of potential funding agencies/calls by area, with respective specific requirements and detailed application structures	**NEW**
A5	Help with negotiating contracts with funders and industry	**NEW**
	Help with negotiating collaboration agreements; ensure ethics permissions are in place	V5
A6	Spending and budget reporting	V12
	Human resources, timekeeping, and payroll	V23
	Proposal preparation	**NEW**
A7	More 'marketing and lobbying role' that seeks to promote the work of the institute and also lobby for future stability	V21
	Support the internal success of the teams	V23
A8	Institution Research Board	V17
A9	Keep an eye on ongoing projectification and find a role for PMO in a changing environment	V11
A10	Manage ethic approvals	V4
A11	Management of new leads and proposals	**NEW**
A12	Project Managers themselves are critical for our research institute to bring in funds and execute research projects, disseminate results all in support of the PI and the project team in general	V11
	Our PMO director manages workforce and assigns project managers to appropriate projects	V20
	They are typically setting agendas and convening teams regularly	V22

ID	Respondents' valid answers	Reference to Table 10
	Project Managers themselves are critical for our research institute to develop proposal	**NEW**
A13	Our PMO just does the accounts; we lecturers do almost everything else	V12
A14	Pre-feasibility risk assessment of projects	V13
A15	Provide business development function for translational research, IP support	V11
A16	Provide guidance on and ensure compliance with the ethical standards required by both the research center and the funding body	V11
	Provide guidance/ensure compliance around the Open Access requirements of each funder	V15
A17	Simply having more "update" meetings is not useful and is in fact detrimental to actually getting anything done. A PMO needs to be careful not to get in the way of the R&D. A PMO should be there to support the R&D. The R&D is not there to justify the existence of the PMO. University administrator types tend to forget which way round this relationship needs to go	V11
A18	Social networking among the staff	V4
	Free flow of funds to the projects from the core funds which shall be reimbursed at a later stage after getting individual funding	V21
A19	Strategic engagement with client; align projects with strategy of client	V17
A20	Support proposal for funding	**NEW**
A21	Supporting the Department/Center and Lab based administration to provide local control and resources for project management.	V11
A22	Technology transfer or IPR office have to be integrated	V25
A23	The main support that research groups need in the UK context is in ensuring high quality applications for funding are submitted, rather than substituting for project management by researchers	**NEW**
A24	To integrate management coaching methods with different research teams	V3
A25	Establish institutional dialogue with funding institutions, for example to expedite the response to questions and inquires raised during applications or even during projects. This would free the investigator in charge of this task, which requires time that could be allocated to issues more directly related to the ongoing investigation	V16
A26	Supporting the entire reimbursement and procurement bureaucracy during a project	V11
	Assist in prospecting funding sources	V21
	Creation and joining of possible international partners	**NEW**
A27	Add a Strategic Asset Management, as advocated by the AACE International Association, trying to fill gaps in PMI's Organizational Project Management (OPM)	V17
A28	Create project funding list (national and EU projects, etc.)	V21
	Help in the preparation of applications for these projects	**NEW**
A29	Try to establish links and interactions between projects so that they do not grow unarticulated	FR17
A30	Effective support in drafting project funding applications	**NEW**

ID	Respondents' valid answers	Reference to Table 10
A31	Build quality international partnerships in the Research Center's areas of competence that enable successful applications for H2020 European projects. Participate in NPC actions and networking meetings in Brussels	V21
	Collaborate in the submission of funding applications	**NEW**
A32	Financial execution management	V12
	Procurement management	V12
	Hiring management	V23
A33	Management and monitoring of the benefits that were initially attributed to the project and which led to its award over others to ensure the credibility of each project manager when evaluating the project during its study or planning phase	V12
A34	Support in project development, adapting the language to the different financing typologies	**NEW**
A35	Financial and physical controlling	V12
	Search for funding sources	V21

As can be verified in Table 19, through the analysis of the answers given, the exercise of allocating the answers to the initial conceptualization present in Table 10 was performed. It was found that through the 35 valid answers presented, a total of 54 functions were identified. Of these 54 identified functions, it was possible to notice that 41 of them concern to the existing F&R already identified. However, 13 of them concern to functions not previously identified. These functions are identified as *'NEW'* in Table 19. In more detail, it was possible to verify that the answers A2, A4, A6, A11, A12, A20, A23, A28, A30, A31 and A34, were related to support in the submission of applications for funding. In short, of all the valid answers, 31% identified as new function the support in the submission of applications for funding. These results will change the proposed conceptualization as this new identified function will be added to the initial proposed conceptualization. This new function will be discussed in more detail in Section 4.4.

4.3.2 Reliability analysis

The data was analyzed as follows. First, the SPSS software was used. The reliability and validity of the data was tested using Cronbach's alpha and factor analyses respectively. Factor Analysis (FA) is conducted to explore the relation of the functions of the PMOs with the concept of *Basic PMO*, *Intermediate PMO* and *Advanced PMO*, in other words, to verify if the results of the questionnaire led to the aggregation of the functions resulting from the initial conceptualization of *Basic PMO*, *Intermediate PMO* and *Advanced PMO*. In summary, what is intended to validate is the proposal of the initial conceptualization of the PMO structure for URC. Through FA the measurable and observable variables

can be reduced to fewer variables that share a common variance and are unobservable (Bartholomew, Knott, & Moustaki, 2011), which are not directly measured. It is an essential method to simplify complex sets of data (Kline, 1994) and analyze which variables 'go together' (Decoster & Hall, 1998). Second, the interpretations arising from the FA were compared with the typology and functions presented in the initial conceptualization of a PMO that was developed from the literature review.

Before starting the FA, it is necessary to evaluate the factorability of the data collected. For this, it is necessary to verify if the correlation of the majority of the variables is greater than 0.3. If this happens, it indicates that the data collected is adequate for FA. Then, Bartlett's test of sphericity and a Kaiser-Meyer-Olkin (KMO) test were conducted to help assess the factorability of the data collected. In the KMO test, the KMO index ranges from 0 to 1, and the factorial analysis is assumed appropriate only if KMO is higher than 0.6 for a better indicator of factorability (Field, 2017; Kim & Mueller, 1978). As for the Bartlett's test of sphericity, should be less than 0.05 ($p<0.05$) to be significant. After all the test results presented favorable values of FA, the Principal Component Analysis (PCA) was performed. In order to verify the applicability of the data in this analysis and to be able to proceed with FA, it is necessary to verify that the commonalities have values higher than 0.5. These results are extracted through SPSS software package. The next step is the determination of the number of 'factors' that are needed to represent the data through the 'factor extraction' (Kim & Mueller, 1978). Kaiser's test is one of the most commonly used techniques, also known as the eigenvalue rule (Field, 2017). Only the 'factors' with eigenvalue greater than 1 should be considered (Kim & Mueller, 1978). In order to simplify the interpretation of the results and to perceive which variables are part of each factor, the varimax rotation method was performed. Appendix III – SPSS Outputs shows in detail all the outputs extracted from SPSS concerning to the FA analysis.
Table 20 summarizes the FA steps followed in this research and their results. Table 21 presents the varimax rotation and variance explained.

Table 20 – FA steps followed and their results

Steps	Results and Comments: FA#1
Determine if FA is applicable to data set	All items have at least half of more of their correlation > 0.3. All data is suitable for FA.
	KMO = 0.946. The data set has the 'excellent' level for FA (If KMO > 0.9).
	Bartlett's test of sphericity is significant (p ≈ 0.000). The data is factorable.
	All items have communalities above 0.5, expect V1, V9 and V21 very near from 0.5 and V6 very near from 0.4 The data shows factorability.
Determine number of 'factors'	Three 'factors' have an eigenvalue > 1 explaining 62% of the total variance. This is a 3-theme construct.
Develop 'factor' structure	Using rotation results, obtain Factor loading matrix: F1: V15, 17, 18, 19, 20, 21, 22, 23, 24, 25 F2: V7, 9, 10, 11, 12, 13, 14, 16 F3: V1, 2, 3, 4, 5, 6, 8

Table 21 – Rotated Component Matrix

Item	PMO F&R	Component/Factor		
		1	2	3
V1	Develop and manage repositories with past R&D project's information (knowledge management)	0.100	0.348	0.584
V2	Ensure mentoring and coaching on the use of good project management practices by the Principal Investigator and her/his team	0.319	0.237	0.679
V3	Develop project management competences through training, workshops and seminars	0.137	0.340	0.683
V4	Promote social interaction, stimulating research communities/groups in order to strengthen the bonds of trust between the members of the research center	0.436	0.024	0.648
V5	Ensure the cohesion of the team through a clear definition of the R&D projects' objectives, as well as the research center's objectives	0.483	0.024	0.648
V6	Characterize the different types of R&D projects currently at the research center (e.g., collaborative university-industry R&D projects)	0.118	0.367	0.483
V7	Develop and implement project management methodologies adjusted to each R&D project type	0.234	0.663	0.426
V8	Create a platform that provides the relevant information of all past and ongoing R&D projects	0.209	0.498	0.504

Item	PMO F&R	Component/Factor		
		1	2	3
V9	Provide, through a platform, updated information about conferences in the different research areas, as well as potential partners for research	0.387	0.491	0.300
V10	Implement and manage a lessons learned database so they can be incorporated in new R&D projects	0.385	0.640	0.398
V11	Carry out specific project management tasks to support the Principal Investigator (e.g., project risk management, conduction of regular progress meetings with the R&D project team)	0.425	0.733	0.203
V12	Provide the Principal Investigator with a periodic report on the current state of the R&D project, particularly in terms of scope, time and cost (e.g. project cockpit chart)	0.411	0.713	0.116
V13	Implement and manage a risk database associated with different types of R&D projects	0.315	0.572	0.394
V14	Provide software tools to support project management	0.146	0.654	0.322
V15	Conduct post-project reviews to ensure the exploitation of the R&D project's results (e.g., verify if the developed products have become commercialized products)	0.508	0.502	0.324
V16	Support the development of technical and financial reports to submit to the funding entity	0.228	0.713	0.025
V17	Participate in the strategic planning of the research center, for the PMO to ensure the alignment of R&D projects with the research center strategy	0.660	0.261	0.368
V18	Identify, select and prioritize the new ideas for R&D projects	0.778	0.215	0.187
V19	Ensure the quality of the different R&D projects' management, through dashboards and audits	0.716	0.329	0.254
V20	Manage resource allocation between R&D project (resources capacity management)	0.801	0.205	0.073
V21	Seek funding for the development of R&D projects: networking and lobbying	0.544	0.353	0.277
V22	Conduct follow-up meetings with each R&D project team to ensure the management and project status update of the R&D projects at the research center	0.721	0.339	0.318
V23	Manage the allocation of human resources to research, in particular identifying areas lacking or with excess human resources, i.e., balancing the research capacities	0.780	0.248	0.204
V24	Monitor and control the performance of R&D projects in order to report the status of the R&D projects portfolio to the research center's board	0.796	0.278	0.176
V25	Manage the exploitation of the results of each R&D project (e.g., knowledge and technology transfer, namely through university-industry interface units)	0.648	0.238	0.362
	Eigenvalues	12.503	1.750	1.325
	Percent of variance explained %	50.013	6.999	5.301

Taking in account the results obtained, it is determined that:

Factor (component) 1: this factor is constituted by ten variables, all strongly correlated positively: V15, V17, V18, V19, V20, V21, V22, V23, V24 and V25. Therefore, this factor corresponds to *Advanced PMO* of the initial conceptualization.

Factor (component) 2: this factor is constituted by eight variables, all strongly correlated positively: V7, V9, V10, V11, V12, V13, V14 and V16. Therefore, this factor corresponds to *Intermediate PMO* of the initial conceptualization.

Factor (component) 3: this factor is constituted by seven variables, all strongly correlated positively: V1, V2, V3, V4, V5, V6 and V8. Therefore, this factor corresponds to *Basic PMO* of the initial conceptualization.

Once established the final structure of all factors, it is necessary to conduct reliability analysis, using Cronbach's alpha analysis, presented in the Table 22. The results obtained are reliable since Cronbach's alpha values are all higher than 0.7 (Nunnally & Bernstein, 1994).

Table 22 – Cronbach's alpha analysis

Theme ('Factor' in FA)	Cronbach's alpha
F1: V15, 17, 18, 19, 20, 21, 22, 23, 24, 25	0.938
F2: V7, 9, 10, 11, 12, 13, 14, 16	0.900
F3: V1, 2, 3, 4, 5, 6, 8	0.830

To summarize, the results of the reliability analysis slightly differ from the initial conceptualization proposed. The results still suggest the presence of twenty-five F&R in the conceptualization. However, what varies is the distribution of F&R among the types of PMOs: *Basic*, *Intermediate* and *Advanced PMO*. The distribution of F&R by PMOs is as follows:

- Basic PMO: V1, V2, V3, V4, V5, V6 and V8 (seven F&R)
- Intermediate PMO: V7, V9, V10, V11, V12, V13, V14 and V16 (eight F&R))
- Advanced PMO: V15, V17, V18, V19, V20, V21, V22, V23, V24 and V25 (ten F&R)

4.4 Questionnaire findings

In general, the questionnaire's results suggest that the initial conceptualization was not well structured, since there was a need to change some (three) the suggested F&R in each type of PMO proposed,

specifically F&R V6, V8 and V15. Following, in more detail, the changes suggested by the questionnaire's results are analyzed.

Regarding the V6, the highest loading value was 0.483 in Factor 3, identified as *Basic PMO*. In the initial conceptualization, this function was designed into the *Intermediate PMO*. This change makes sense as this function is related to the identification and categorization of all the existing projects within the URCs. This function should be one of the first roles for a PMO to assist the organization in project classification and prioritization. Therefore, in the PMO final conceptualization this function moved to the *Basic PMO*.
Regarding the V8, the highest loading value was in Factor 3, related to the *Basic PMO*. In the initial conceptualization this function was designed into the *Intermediate PMO*, and as can be verified, there was a slight difference between the loading values of Factors 2 and 3, respectively, 0.498 and 0.504. For that reason, and taking into consideration the content of this function, creating a platform that provides information on past and ongoing projects, which requires a high effort to put in place, therefore this function was maintained in the *Intermediate PMO.* Additionally, this function also can be seen as an evolution of the V6, because in order to create a platform with project information, it is necessary to have information related to the characterization of projects (V6).
Regarding the V15, the highest loading value was in Factor 1, related to the *Advanced PMO*. In the initial conceptualization this function was designed into the *Intermediate PMO*, and as can be verified, there was a slight difference between the loading values of Factors 1 and 2, respectively, 0.508 and 0.502. Analyzing it makes sense that this function should be in the *Advanced PMO*, since the guarantee of the exploitation of the R&D project's results should be performed by an experienced team that is close to the strategic level of the organization. So, for that reason, this function is justified in the *Advanced PMO*.

Moreover, it should be noted that 31% of the respondents who answered the open question pointed as useful a new F&R associated to the *'Support in the submission of applications for funding'*. For this reason, it was considered of great importance to include this F&R in the proposed conceptualization. This new F&R (named by V26) was placed in the *Intermediate PMO* along with the function V16 *(Support the development of technical and financial reports to submit to the funding entity)*, because the two functions complement each other, since applications often require the completion of technical and financial reports.

In conclusion, from the analysis of the questionnaire's results resulted a new proposal of conceptualization with a total of twenty-six F&R divided into three PMO typologies that the PMO structure should assume for the adequate support to the management of projects in URC context: six F&R to *Basic PMO*, ten F&R to *Intermediate PMO*, and ten F&R to *Advanced PMO*. Table 23 presents the final conceptualization proposed. The conceptualization presents a logical evolution, with functions attributed to each PMO, implying that the PMO is supposed to evolve in all PM tasks, not fixing itself in a typology.

Table 23 – Proposed conceptualization resulting from the analysis of questionnaire's results

PMO type	Survey/ Item	PMO F&R
Basic PMO	V1	Develop and manage repositories with past R&D project's information (knowledge management)
	V2	Ensure mentoring and coaching on the use of good project management practices by the principal investigator and her/his team
	V3	Develop project management competences through training, workshops and seminars
	V4	Promote social interaction, stimulating research communities/groups in order to strengthen the bonds of trust between the members of the research center
	V5	Ensure the cohesion of the team through a clear definition of the R&D projects' objectives, as well as the research center's objectives
	V6	Characterize the different types of R&D projects currently at the research center (e.g., collaborative university-industry R&D projects)
Intermediate PMO	V7	Develop and implement project management methodologies adjusted to each R&D project type
	V8	Create a platform that provides the relevant information of all past and ongoing R&D projects
	V9	Provide, through a platform, updated information about conferences in the different research areas, as well as potential partners for research
	V10	Implement and manage a lessons learned database so they can be incorporated in new R&D projects
	V11	Carry out specific project management tasks to support the principal investigator (e.g., project risk management, conduction of regular progress meetings with the R&D project team)
	V12	Provide the principal investigator with a periodic report on the current state of the R&D project, particularly in terms of scope, time and cost (e.g. project cockpit chart)
	V13	Implement and manage a risk database associated with different types of R&D projects
	V14	Provide software tools to support project management
	V26	Support in the submission of applications for funding

PMO type	Survey/ Item	PMO F&R
	V16	Support the development of technical and financial reports to submit to the funding entity
Advanced PMO	V15	Conduct post-project reviews to ensure the exploitation of the R&D project's results (e.g., verify if the developed products have become commercialized products)
	V17	Participate in the strategic planning of the research center, for the PMO to ensure the alignment of R&D projects with the research center strategy
	V18	Identify, select and prioritize the new ideas for R&D projects
	V19	Ensure the quality of the different R&D projects' management, through dashboards and audits
	V20	Manage resource allocation between R&D project (resources capacity management)
	V21	Seek funding for the development of R&D projects: networking and lobbying
	V22	Conduct follow-up meetings with each R&D project team to ensure the management and project status update of the R&D projects at the research center
	V23	Manage the allocation of human resources to research, in particular identifying areas lacking or with excess human resources, i.e., balancing the research capacities
	V24	Monitor and control the performance of R&D projects in order to report the status of the R&D projects portfolio to the research center's board
	V25	Manage the exploitation of the results of each R&D project (e.g., knowledge and technology transfer, namely through university-industry interface units)

4.5 Comparison of results

As explained above, this section presents the comparison of the results obtained by the dissemination of the questionnaire between this research and Ferreira's (2016) research. It is worth mentioning that this research is a continuation of the Ferreira's research. Ferreira's (2016) research focused on the dissemination of a questionnaire at a population sample in Portugal. The current research encompasses the work done by Ferreira, disseminating the questionnaire at an international level. Therefore, in this research, the final results include data obtained through international dissemination and data obtained in Ferreira's research from its dissemination in a particular context (Portugal).

The comparison of results between both researches will focus on the data obtained in question 12 (open answer question) and the data obtained by the reliability analysis.

Through the analysis of the data collected from question 12, in both researches, it was possible to verify that, approximately, 25% of the respondents pointed out as useful a new function associated to the support in the submission of applications for funding. Due to the results presented, the inclusion of one more F&R to the initial conceptualization proposed was considered. Therefore, in both researches, it was

considered for the conceptualization resulting from the analysis of the questionnaire's results the introduction of a new F&R, named by V26 *(Support in the submission of applications for funding)*, that was allocated to the *Intermediate PMO*, along whit the F&R *V16 (Support the development of technical and financial reports to submit to the funding entity)*.

From the results of the reliability analysis of both researches it was possible to verify small differences that affect the conceptualization to be proposed. Table 24 shows the results' comparison of reliability analysis of both researches.

Table 24 – Comparison of varimax rotation and variance explained

Item	Component/Factor			Factor in Ferreira (2016)		
	1	2	3	1	2	3
V1	0.100	0.348	0.584	0.048	0.382	0.689
V2	0.319	0.237	0.679	0.467	0.248	0.609
V3	0.137	0.340	0.683	0.281	0.244	0.708
V4	0.436	0.024	0.648	0.478	0.145	0,679
V5	0.483	0.024	0.648	0.476	0.077	0.731
V6	0.118	0.367	0.483	0.222	0.489	0.586
V7	0.234	0.663	0.426	0.315	0.666	0.439
V8	0.209	0.498	0.504	0.222	0.562	0.536
V9	0.387	0.491	0.300	0.409	0.465	0.416
V10	0.385	0.640	0.398	0.440	0.559	0.457
V11	0.425	0.733	0.203	0.312	0.827	0.172
V12	0.411	0.713	0.116	0.324	0.825	0.198
V13	0.315	0.572	0.394	0.310	0.483	0.501
V14	0.146	0.654	0.322	0.221	0.760	0.266
V15	0.508	0.502	0.324	0.514	0.391	0.450
V16	0.228	0.713	0.025	0.227	0.839	0.151
V17	0.660	0.261	0.368	0.636	0.348	0.442
V18	0.778	0.215	0.187	0.751	0.233	0.269
V19	0.716	0.329	0.254	0.770	0.293	0.273
V20	0.801	0.205	0.073	0.841	0.266	0.122
V21	0.544	0.353	0.277	0.444	0.532	0.306
V22	0.721	0.339	0.318	0.671	0.295	0.476
V23	0.780	0.248	0.204	0.814	0.217	0.236
V24	0.796	0.278	0.176	0.775	0.363	0.225
V25	0.648	0.238	0.362	0.645	0.320	0.378
Eigenvalues	12.503	1.750	1.325	14.402	1.824	1.283
Percent of variance explained %	50.013	6.999	5.301	57.606	7.295	5.131

As can be verified, in both researches, the results suggested the reallocation of some F&R in a different PMO from those defined in the initial conceptualization proposed: three in the current research (V6, V8 and V15); and four in the Ferreira's research (V6, V13, V15 and V21).

After analyzing the reallocation of the results suggested, both researches proposed a different conceptualization. In a nutshell, as can be verified in Table 25, the results of this current research suggest a new proposal of conceptualization with a total of twenty-six F&R: six F&R to *Basic PMO*, ten F&R to *Intermediate PMO*, and ten F&R to *Advanced PMO*. Instead, the Ferreira's research suggests a new proposal of conceptualization with a total of twenty-six F&R: seven F&R to *Basic PMO*, ten F&R to *Intermediate PMO*, and nine F&R to *Advanced PMO*.

Table 25 – Conceptualization proposed by analyzing the questionnaire's results

PMO	Current research	Ferreira's research
Basic PMO	V1, V2, V3, V4, V5, V6	V1, V2, V3, V4, V5, V6 and V13
Intermediate PMO	V7, V8, V9, V10, V11, V12, V13, V14, V16 and V26	V7, V8, V9, V10, V11, V12, V14, V16, V21 and V26
Advanced PMO	V15, V17, V18, V19, V20, V21, V22, V23, V24 and V25	V15, V7, V18, V19, V20, V22, V23, V24 and V25

5. CASE STUDY

5.1 Introduction

This chapter presents an analysis and findings of the interviews research phase and is divided into five sections. In order to summarize all the interview research phase, this section presents some information about the interview's data analysis. The next section presents a description of the process of conducting the interviews, including an interviewees' brief characterization. The following section presents the interviews' analysis performed. The fourth section presents the interviews' findings. Then, a summary of findings is presented in the last section.

The interviews' analysis allowed the researcher to identify the most and least useful F&R of a PMO structure to support a particular URC context – University of Minho case study.

One of the objectives for conducting the interviews in this research was to obtain information from researchers that work at research centers from University of Minho. Therefore, as mentioned in section 3.8.2, the researcher identified twenty-four potential researchers that might be willing to participate on the research (see Table 5). All the potential researchers identified were contacted via personal contacts, by phone and/or email, to request them to conduct the interviews. Of all the researchers contacted, and considering the temporal restriction imposed for conducting the interviews, only twelve researchers showed willingness to collaborate in this research and agreed to be interviewed.

Although a small number of interviews were conducted, the researcher observed that the information collected during the last interviews did not add practically any new and relevant information. In all, as indicated in Table 26, structured interviews were carried out in seven research centers. Table 27 shows in detail the researchers' characterization who agreed to conduct the interviews.

Table 26 – URC' list interviewed

Research center	Research area	Number of interviews
ALGORITMI Research Center	Information and Communications Technology and Electronics (ICT&E)	5
Center for Computer Graphics, CCG	Computer graphics, information, communication and Electronic technologies	1
Centre for Mechanical and Materials Technology, CT2M	Mechanical and Materials Technology	1
Centre of Physics of the University of Minho and Porto, CF-UM-UP	Physics	1
DONE Lab - Advanced Manufacturing of Products and Tools	Advanced Manufacturing	1
Institute of Polymers and Composites, IPC	Polymers and Composites	2
Research Group on Quality and Organizational Excellence, RG-QOE	Quality and Organizational Excellence	1

5.2 Conducting the interviews

The interviews were conducted between February and May 2019. Wherever possible, the interviews were conducted in person at the interviewees' organizations. Before the interview, all participants had received by email a document named *'Conceptualization of a project management office (PMO) to support university research centers (URC)'* (see Appendix II – Interview Documentation). All the interviews started with an introduction about the researcher's personal background, with an outline of the research objectives and the definition of some terms used in the study. The researcher asked for authorization to take notes and tape-record and assured the interviewee of the confidentiality of the interview and that the data obtained would be used only for academic purposes.

The average duration of interviews was half an hour. In the interview, the researcher focused on identifying the interviewees' perspective on the most useful F&R of a PM structure to support their research center. Appendix II – Interview Documentation presents the interview protocol used.

Table 27 shows all the information concerning to the interviewees' characterization, namely, research center, research project area, primary role, gender, education level and PM experience. As can be verified, the interviewees were from different research areas and had different roles in their research center (see Figure 8): team members (50%), directors or coordinators (42%) and project managers (8%).

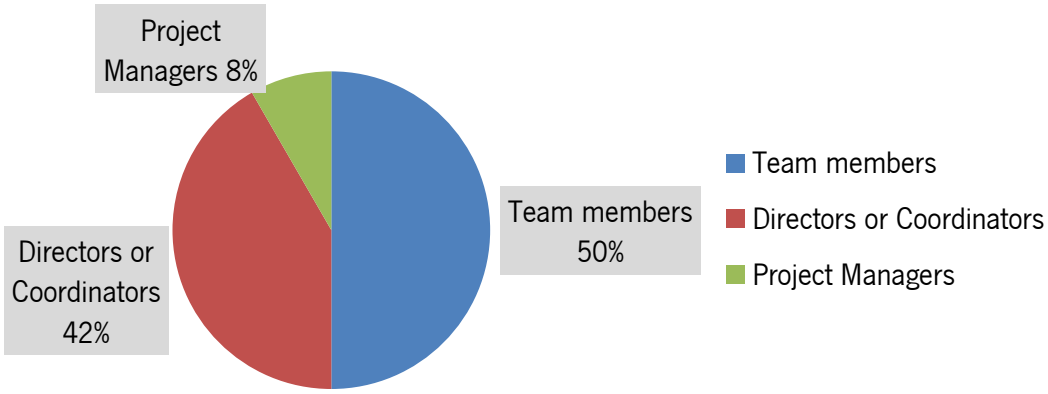

Figure 8 – Interviewees' role at research center

Table 27 – Expert group interviewees' characterization

ID	Gender	Research area	Research center	Function	PM experience	Education level
R1	Male	Embedded Systems, Instrumentation Systems and Microelectric-mechanical systems	ALGORITMI Research Center	Researcher with PhD Assistant Director of the ALGORITMI Research Centre Member of the IE R&D Line Member of the ESRG R&D Group	> 10 years	PhD
R2	Female	Economics of Engineering Systems and Management	ALGORITMI Research Center	Researcher with PhD Member of the IEM R&D Line Member of the EMES R&D Group Coordinator of the IEM R&D Line	> 10 years	PhD
R3	Female	Logistics and Supply Chain Management	ALGORITMI Research Center	Researcher with PhD Assistant Director of the ALGORITMI Research Centre Member of the IEM R&D Line Member of the SLOTS R&D Group Leader of the SLOTS R&D Group	4 – 6 years	PhD

ID	Gender	Research area	Research center	Function	PM experience	Education level
R4	Male	Ergonomics and Human Factors	ALGORITMI Research Center	Researcher with PhD Member of the IEM R&D Line Member of the EHF R&D Group	7 – 10 years	PhD
R5	Male	Engineering Economics	ALGORITMI Research Center	Researcher with PhD Member of the IEM R&D Line Member of the SLOTS R&D Group	> 10 years	PhD
R6	Male	Industrial engineering and management	Center for Computer Graphics, CCG	Program Manager	> 10 years	MSc
R7	Male	Mechanical, metallurgical and biological characterization	Centre for Mechanical and Materials Technology, CT2M	Researcher with PhD	> 10 years	PhD
R8	Male	Atomic and Molecular Physics	Centre of Physics of the University of Minho and Porto, CF-UM-UP	Researcher with PhD	> 10 years	PhD
R9	Male	User-Centered Design and Additive Manufacturing technology	DONE Lab - Advanced Manufacturing of Products and Tools	Co-Founder & COO	4 – 6 years	PhD
R10	Female	Surface and interfacial modification of carbons nanomaterials	Institute of Polymers and Composites, IPC	Researcher with PhD	> 10 years	PhD
R11	Male	Degradable and biodegradable polymeric materials and nanocomposites	Institute of Polymers and Composites, IPC	Researcher with PhD	1 - 3 years	PhD
R12	Male	Quality and Organizational Excellence	Research Group on Quality and Organizational Excellence, RG-QOE	Researcher with PhD Coordinator	> 10 years	PhD

The interviewees had a high level of education: 11 with PhD degree and 1 with MSc degree. Most of the participants were male (75%). The interviewees had a high PM experience (see Figure 9): 67% had more than 10 years of PM experience, 17% had 4 to 6 years, 8% had 7 to 10 years and 8% had less than 1 year of PM experience.

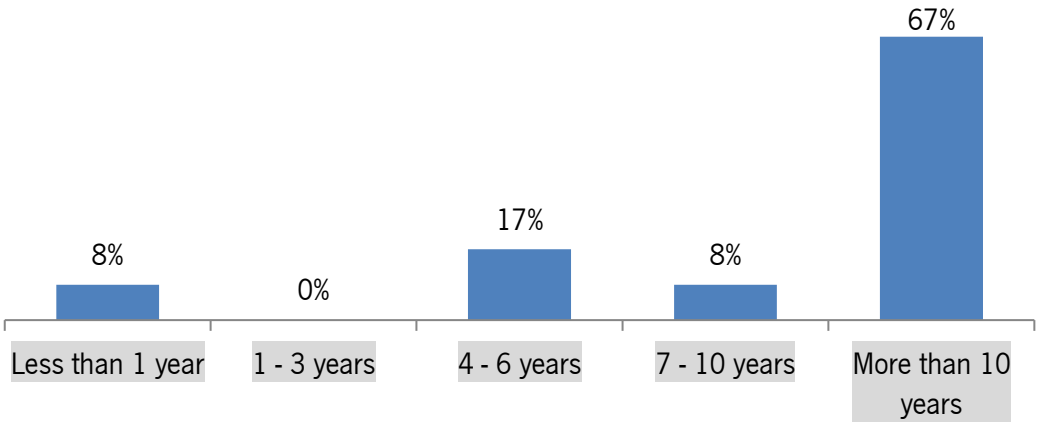

Figure 9 – Interviewees' PM experience

5.3 Analyzing interviews data

The technique used to the analysis of the structured interviews data was the thematic analysis, as thematic analysis represents a formal approach to qualitative data analysis (Miles & Huberman, 1994).

Firstly, it was possible to verify that all the interviewees perceive value in the existence of a support structures for PM in their research center, even knowing that there is no associated structure in their research center.

In relation to the usefulness of the PMO F&R presented, it was possible to verify that, in general, all interviewees consider that most F&R are important in supporting PM, since 88% of the responses correspond to the *medium*, *high* and *very high* utility levels. In particular, when the median values of the given responses were analyzed, it was verified that all F&R have responses at the utility levels discussed above. See Figure 10 for more detail.

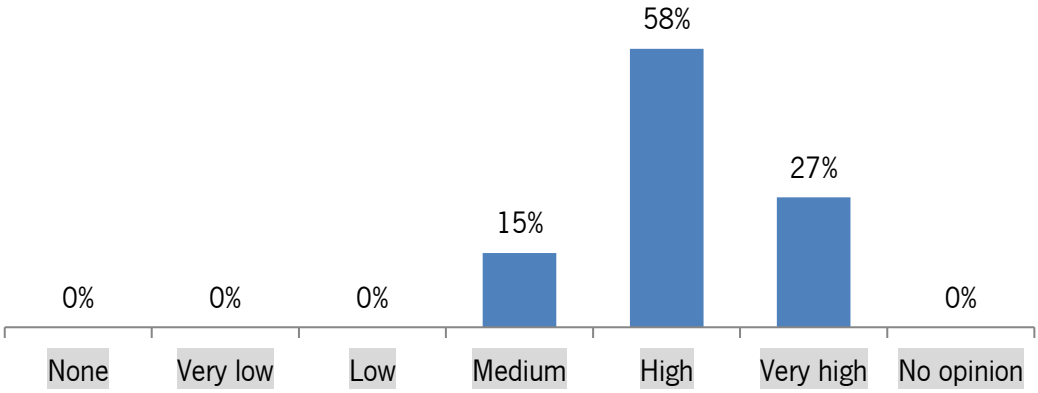

Figure 10 – Median values of utility levels obtained

Table 28 shows in detail the percentage of the given responses by utility level in each F&R.

Table 28 – Interviewees results

Item	PMO F&R	None %	Very low %	Low %	Medium %	High %	Very high %	No opinion %
V1	Develop and manage repositories with past R&D project's information (knowledge management)	8	0	8	17	25	42	0
V2	Ensure mentoring and coaching on the use of good project management practices by the principal investigator and her/his team	0	0	17	8	42	25	8
V3	Develop project management competences through training, workshops and seminars	0	0	8	25	50	9	8
V4	Promote social interaction, stimulating research communities/groups in order to strengthen the bonds of trust between the members of the research center	0	0	25	42	25	8	0
V5	Ensure the cohesion of the team through a clear definition of the R&D projects' objectives, as well as the research center's objectives	0	0	0	25	42	33	0
V6	Characterize the different types of R&D projects currently at the research center (e.g., collaborative university-industry R&D projects)	0	0	8	25	50	17	0

Item	PMO F&R	None %	Very low %	Low %	Medium %	High %	Very high %	No opinion %
V7	Develop and implement project management methodologies adjusted to each R&D project type	0	0	0	17	25	58	0
V8	Create a platform that provides the relevant information of all past and ongoing R&D projects	0	0	8	25	25	42	0
V9	Provide, through a platform, updated information about conferences in the different research areas, as well as potential partners for research	0	17	0	33	17	33	0
V10	Implement and manage a lessons learned database so they can be incorporated in new R&D projects	0	0	0	8	42	50	0
V11	Carry out specific project management tasks to support the principal investigator (e.g., project risk management, conduction of regular progress meetings with the R&D project team)	0	0	8	0	17	75	0
V12	Provide the principal investigator with a periodic report on the current state of the R&D project, particularly in terms of scope, time and cost (e.g. project cockpit chart)	0	0	0	0	8	92	0
V13	Implement and manage a risk database associated with different types of R&D projects	0	0	0	16	42	42	0
V14	Provide software tools to support project management	0	0	17	8	33	42	0
V15	Conduct post-project reviews to ensure the exploitation of the R&D project's results (e.g., verify if the developed products have become commercialized products)	0	0	0	33	33	34	0
V16	Support the development of technical and financial reports to submit to the funding entity	0	0	0	0	17	83	0
V17	Participate in the strategic planning of the research center, for the PMO to ensure the alignment of R&D projects with the research center strategy	0	0	8	8	67	17	0
V18	Identify, select and prioritize the new ideas for R&D projects	0	17	17	25	33	8	0

Item	PMO F&R	None %	Very low %	Low %	Medium %	High %	Very high %	No opinion %
V19	Ensure the quality of the different R&D projects' management, through dashboards and audits	0	0	17	8	42	33	0
V20	Manage resource allocation between R&D project (resources capacity management)	8	0	33	17	42	0	0
V21	Seek funding for the development of R&D projects: networking and lobbying	0	0	0	25	42	33	0
V22	Conduct follow-up meetings with each R&D project team to ensure the management and project status update of the R&D projects at the research center	0	0	0	8	33	59	0
V23	Manage the allocation of human resources to research, in particular identifying areas lacking or with excess human resources, i.e., balancing the research capacities	8	9	33	17	33	0	0
V24	Monitor and control the performance of R&D projects in order to report the status of the R&D projects portfolio to the research center's board	0	0	8	25	33	34	0
V25	Manage the exploitation of the results of each R&D project (e.g., knowledge and technology transfer, namely through university-industry interface units)	0	0	24	17	42	17	0
V26	Support in the submission of applications for funding	0	0	0	8	17	75	0

From all the F&R presented, the interviewees were challenged to identify the three most useful and the three least useful. Figure 11 and Figure 12 show, respectively, the most and least useful F&R according to all the interviewees. As can be verified, the three most voted as the most useful were V16 with 8 votes, followed by V12 and V11 with, respectively, 7 and 6 votes. The three most voted as the least useful were V23 with 8 votes, followed by V20 and V18 with, respectively, 6 and 4 votes.

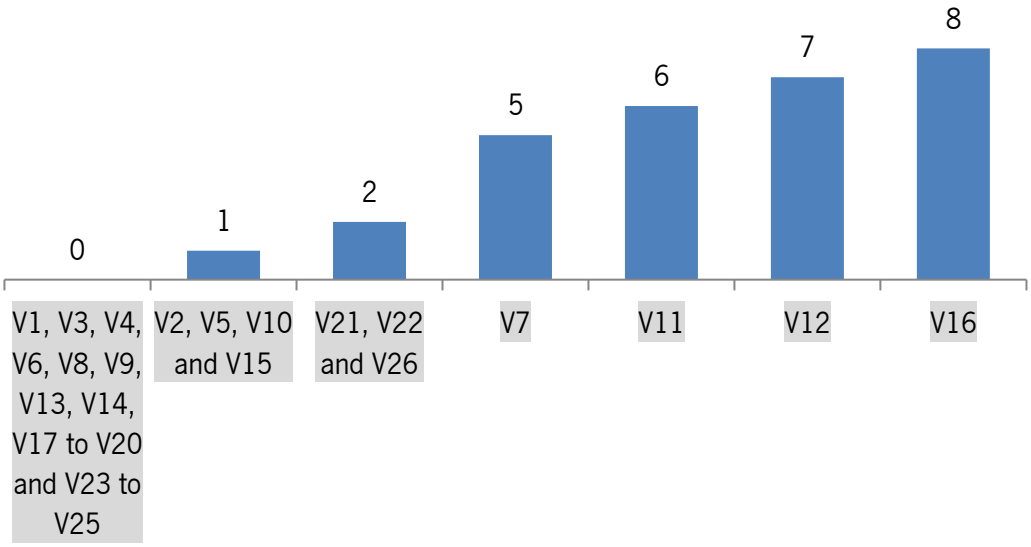

Figure 11 – The most useful F&R obtained

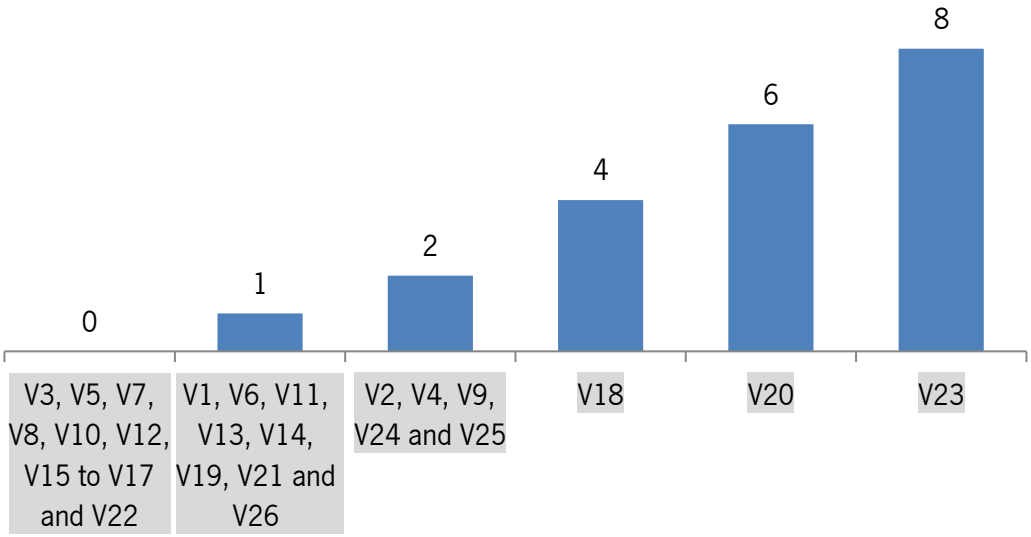

Figure 12 – The least useful F&R obtained

5.4 Interviews findings

The interviews' results show that, in a general way, the F&R fit and are fundamental for a structure to support PM in URC.

Interviewees, after indicating the usefulness of the presented F&R, were challenged to identify those they consider to be the three most and least useful functions of all presented (question 3 of the interview). As can be seen, the interviewees demonstrate *high* or *very high* utility in the F&R presented, identifying as

most useful functions the V16, V12 and V11, with, respectively, 67%, 58% and 50%, and the least useful ones the V23, V20 and V18, with, respectively, 67%, 50% and 33%.

Below, the main answers to question 3 of the interviews are presented. First, in section 5.4.1, the main justifications for the F&R considered most useful are presented (V16, V12, V11, V7, V21, V22 and V26). Then, in section 5.4.2, justifications for the least useful ones appear (V23, V20, V18, V2, V4, V9, V24 and V25).

5.4.1 Most useful F&R

The interviewees' justifications for choosing the most useful F&R are presented below.

V16 – Support the development of technical and financial reports to submit to the funding entity

Of all the interviewees, eight considered this one of the most useful and important function. Interviewees justified the choice of V16 by stating that this type of support would make the tasks more professional and free up time to Principal Investigator (PI) to focus on the investigation because with the accumulation of projects it becomes difficult for the PI to respond in a timely manner to these requests.

For example, interviewee R9 stated that *'In the initial phase of each project it is important as it fits in terms of nomenclature and content level errors (especially in larger projects).'*

Interviewee R10 also agreed with the usefulness of this function by stating that *'This type of support would make reporting tasks more expeditious and professional in technical and financial terms.'*

Another interviewee stated that this function it would be important to *'(...) assist in the execution of technical and financial reports to be reported to the funding entity, as the accumulation of projects makes it difficult to respond to these requests in a timely manner'* (interviewee R5).

Likewise, interviewee R4 suggested that *'(...) projects have too much bureaucracy. The resolution of the bureaucracy takes investigation time to the principal investigator.'*

In an effusively way the interviewee R6 stressed that *'(...) the quality and degree of compliance with the technical and financial reports to be reported to the funding entity is the most important of project management. The rest only begins to be important after this goal is met.'*

V12 – Provide the Principal Investigator with a periodic report on the current state of the R&D project, particularly in terms of scope, time and cost (e.g. project cockpit chart)

Following F&R V16, this function appears with seven interviewees considering it as one of the most useful functions. It was consensus of the interviewees that the choice of V12 was justified by the fact that regular meetings and the status of a project, when based on coherent methodologies, carried out by another project team (PMO), is a very important and decisive instrument for the success of a project, helping the PI in decision making.

To reinforce the choice, the interviewee R12 stated that *'I see the project manager as a key resource supporting the principal researcher in the efficient development of the project.'*

Interviewee R6 pointed that the *'Support and feedback to the lead investor is very important in technical and financial compliance. It is a way to avoid problems and becomes important, especially when there are several institutions or partners involved.'*

Other direct and concise opinions came from the interviewees R9 and R4. Interviewee R9 pointed out that *'(...) always know, and in "real time", the state of a project is essential! (...)'*, and interviewee R4 stated that *'The projects have too much bureaucracy that takes research time away from the principal investigator.'*

Similarly, the interviewee R1 stated the importance of this function justifying that *'Providing a periodic status is a very important resource for the PI to manage and decisive as best as possible, thus contributing to the success of the project.''*

V11 – Carry out specific project management tasks to support the Principal Investigator (e.g., project risk management, conduction of regular progress meetings with the R&D project team)

Still in the range of the most useful functions, this function appears. Six interviewees considered it as one of the most important. In all, all the interviewees stated that this function, when well performed, ensures greater confidence for researchers, since by ensuring management tasks, there is greater control over the project.

Interviewee R1 pointed out that *'(...) a good PMO team adds an extra layer of management and control (including risk analysis). It increases the confidence of the researchers (team) because they know that there are external control mechanisms.'*

In the same way, interviewee R12 pointed out: *'I see the project manager as a key resource supporting the principal researcher in the efficient development of the project.'*

Interviewee R5 also considered this one of the most useful functions, but warned that *'(...) it will require the PMO to have an in-depth knowledge of the area in which the projects belong so that the execution of specific project management tasks to support the PI be fruitful.'*

On the other hand, one interviewee expressed dislike for this function, indicating it as one of the least useful functions of all presented. Interviewee R6 stated that this function is the responsibility of the project leader, not the PMO team: *'(...) technical risk management and coordination of work programs should be the clear responsibility of the project leaders. PMOs can and should help. But the responsibility must clearly lie with the project leaders. Otherwise there is a risk of liability and only the management of the IPs can take care of the good technical progress of the projects.'*

V7 – Develop and implement project management methodologies adjusted to each R&D project type

Six interviewees considered this one of the most useful functions. In a general way, the interviewees justified that this function ensures good project performance. The interviewee R1 reinforced saying that *'(...) the implementation of management methodologies is based on the experience of other projects and these methodologies are very important to increase the researchers' confidence in the PMO team. They enable simple integration and a greater focus on critical R&D components for project development. There is no need to draw everything from scratch, especially for more complex projects.'*

And, interviewee R9 stated that this function *'(...) ensures a direct and personalized support to each project, and the methodology marks paths of resolution.'*

V21 – Seek funding for the development of R&D projects: networking and lobbying

This function was considered one of the most useful by two interviewees. The most complete justification came from interviewee R10: *'We have a clear lack of networking and lobbying capacity that is urgently needed to be addressed.'*

V22 – Conduct follow-up meetings with each R&D project team to ensure the management and project status update of the R&D projects at the research center

Two interviewees defended this function as one of the most useful. Interviewee R10 stated that: *'Support for projects in non-technical/scientific areas is important, allowing teachers/researchers to be freed up to support more projects.'*

With another view, interviewee R11 pointed out that *'(...) the PMO team must understand the progress of the work, perceive critical tasks and define contingency plans for the correct fulfillment of the various project objectives. An entity above the research team is required to perform the function of aggregating an overview of project developments.'*

V26 – Support in the submission of applications for funding

It is important to remember that this function was included in the conceptualization after analyzing the questionnaire results, as 26% of the respondents indicated it as useful. Through the interviews it was possible to verify that two interviewees considered this one of the most useful functions. This result is in line with the results obtained by the dissemination of the questionnaire.

Interviewee R5 stated that the *'(...) support the submission of funding applications is very important as the principal researchers need to focus on the scientific objectives of the proposals rather than the administrative aspects of the applications.'*

Interviewee R6 pointed out that *'(...) the compliance with the application procedures and the coordinated integration of contributions from different institutions or partners is key to successful applications.'*

5.4.2 Least useful F&R

As mentioned above in this chapter, the interviewees' justifications for choosing the least useful F&R are presented below.

V23 – Manage the allocation of human resources to research, in particular identifying areas lacking or with excess human resources, i.e., balancing the research capacities

For the least useful functions, eight interviewees indicated that this function should not be assumed by the PMO team. Interviewee R2 was very clear in stating that *'(...) this is solely the responsibility of the principal investigator or project leaders, not the PMO team. It is the principal investigator or project leaders*

who have the ability to analyze and understand which skills or human resources are missing for certain project roles and tasks.'

Likewise, interviewee R9 pointed out that *'This task must be the responsibility of the Principal Investigator and other researchers closest to the project.'*

In its turn, interviewee R10 stated that *'This function is not necessary, because when each project starts, the human resources are distributed and the necessary ones are hired; only punctually imbalances are observed.'*

V20 – Manage resource allocation between R&D project (resources capacity management)

The same justification was given for the choice of V20. This type of F&R - *Manage human resources and resource allocation* - are the entire responsible of the PI or Project Manager and PMO team has the function of supporting with information pertinent to decision making and not having the function of managing the resources.

In the light of the mentioned in V23, Interviewee R2 was very clear in stating that *'(...) this function must be the responsibility of the Principal Investigator or project leaders (...)'*

With the same opinion, Interviewee R9 stated that *'Once again, it seems to me to be the responsibility of the Principal Investigator.'*

V18 – Identify, select and prioritize the new ideas for R&D projects

The interviewees also considered V18 as one of the least useful functions because *'(...) this requires some specific technical knowledge and can be difficult to achieve by the PMO team'* (interviewee R4) that, as a rule, has a lot of management knowledge and not so much technical knowledge on the subject. Therefore, as interviewee R11 pointed out *'(...) the PMO team's help in this function would be to collect information from all those involved so that the PI or Project Manager can prioritize the new ideas for R&D projects.'*

V2 – Ensure mentoring and coaching on the use of good project management practices by the principal investigator and her/his team

Two interviewees also considered V2 as one of the least useful functions because, according to the interviewees, this function must be performed by the PI or research team. Interviewee R4 stated that *'this is a relevant task, but it will not be expected that the PMO will be responsible for its execution.'*

With the same point of view, interviewee R11, pointed out that *'(...) this function clearly has to be assumed by the leader or the research team (...) it should not be taken over by the PMO team at all.*

V4 – Promote social interaction, stimulating research communities/groups in order to strengthen the bonds of trust between the members of the research center

In the light of the exposed above in V2, two interviewees also considered this function as one of the least useful functions because, according to the interviewees R4 and R11, this function must be performed by the PI or research team. To reinforce his option the interviewee R4 pointed out: *'Once again, it will not be expected that the PMO will be responsible for the execution of this function.'*

V9 – Provide, through a platform, updated information about conferences in the different research areas, as well as potential partners for research

Two interviewees also considered this function as one of the least useful functions and their justifications cannot be more assertive.

In the opinion of the interviewee R1 *'(..) PMO teams cannot be involved in conference or newspaper selection (...) Just indicate the objectives of the project in relation to the number of publications.'*

In turn, the interviewee R12 was also very direct stating that *'These functions are fundamental, but they should not, in my opinion, be carried out by project managers.'* The interviewee R12 reinforced saying that *'(...) The project manager must be focused on managing projects efficiently and supporting Principal Investigators in their development – that is why they are called 'project managers' (...).'*

V24 – Monitor and control the performance of R&D projects in order to report the status of the R&D projects portfolio to the research center's board

This function was also chosen by two interviewees as one of the least useful functions. However only one interviewee demonstrated an assertive justification. Interviewee R10 pointed out that *'(...) with regular support and monitoring of projects this task is redundant.'*

V25 – Manage the exploitation of the results of each R&D project (e.g., knowledge and technology transfer, namely through university-industry interface units)

Two interviewees defended this function as one of the least useful justifying that this function is more strategic than technical and therefore the responsibility must be assumed at a strategic level.

To support this assumption, interviewee R1 pointed out that *'There are other entities that should have this task, but it doesn't seem relevant to a PMO team.'*

In turn, interviewee R5 stated that *'(...) neither the investigators nor the PMO team have the authority to assume this role.'*

5.4.3 Other important F&R identified

After identifying the three most and least useful functions of all presented (question 3 of the interview), interviewees were challenged to identify other important functions that were not identified in the interview structure (question 2 of the interview).

The appropriateness of the F&R provided is justified by the fact that the interviewees were unable to identify as relevant and pertinent any other ones. Only two interviewees listed two F&R that could be included in the list. The first, identified by the interviewee R1, was related to the coordination of all communication between the various projects in which the URC are involved, so that the various researchers have basic knowledge of the nature of the remaining projects in the URC. In the words of the interviewee R1: *'Strategy for the dissemination of R&D results and tasks, both internal (holding URC) and external, through the media.'*

The second, identified by interviewee R2, was related to the development and maintenance of an evaluation panel of the projects in which the URC are involved in order to help strategic decision making by members of direction or administration. In the words of the interviewee R2: *'(...) it is important to ensure that a team evaluates projects and assists decision making by direction or administration.'*

5.5 Summary

First, it should be noted that from the questionnaire's phase resulted in a conceptualization of twenty-six F&R that served as the basis for conducting the interviews.

By analyzing the results obtained in the interviews' phase, it was possible to verify that, in general, all F&R were well proposed and fit into the conceptualization initially idealized. However, it was possible to observe that the least useful F&R pointed out by the researchers was V23 related to manage the allocation of human resources to research. In specific, 67% of the answers of the interviews. Out of curiosity, 19% of the respondents in the questionnaires' results also indicated this function as one of the least useful. Through interviews it was possible to perceive the reason for this result. The interviewees justified the low utility of this function because this function is the direct responsibility of the PI or researcher and not the

responsibility of the PMO team. So, it should not be a role assumed by the PMO team. Interviewees are the opinion that the PI is the one who has the capacity to analyze and predict the allocation of human resources and is responsible for identifying whether or not there is excess of human resources in the most diverse functions.

For all the above, and taking into account the small numbers of interviews conducted, the results of the interviews, by themselves, do not justify to eliminate this function from the initial conceptualization proposed. Thus, the proposed conceptualization will have twenty-six F&R divided into three PMO typologies as explained in section 4.4.

6. Conclusions and Further Research

6.1 Main conclusions

The aim of this research was to identify the main F&R that a PMO should have to support and improve the likelihood of achieving success for research projects in URC context.

The researcher started with a literature review of the main research elements. The proposal takes an evolutionary perspective, suggesting three different typologies of PMOs: *Basic PMO*, *Intermediate PMO* and *Advanced PMO*. The literature review lead to a proposal of an initial conceptualization of the F&R for each one of the three PMO typologies.

The initial proposed conceptualization was tested through a questionnaire, which elicited 370 valid responses from researchers involved in projects at URC. The questionnaire's results were in line with the initial conceptualization proposed, highlighting twenty-six F&R in the set of the three suggested typologies of PMOs: seven for the *Basic PMO*, nine for the *Intermediate PMO*, and ten for the *Advanced PMO*. Then, twelve interviews were carried out to perceive the usefulness of the F&R identified in the proposed conceptualization. By analyzing the results obtained in the interviews' phase, it was possible to verify that all F&R were well proposed and fit into the conceptualization initially idealized.

In short, it can be inferred that the researcher was able to achieve the objectives defined for this research:

> RO_1: To identify the main functions and responsibilities (F&R) associated with a PMO structure in URC contexts.

Through the intense analysis of the literature, the researcher concluded that practically all typologies are based on the typologies proposed by PMI (2017) and proposed a typology with three types of PMOs: *Basic PMO*, *Intermediate PMO* and *Advanced PMO*, with different F&R. See Table 2 (pages 20 and 21) for more detail. This typology served as the basis for the construction and dissemination of the questionnaire. And, it was through the data obtained with the questionnaire that the researcher was able to achieve the RO_1. Table 29 shows the results related to the identification of the main F&R associated with a PMO structure in URC contexts. In conclusion, this research suggests a proposal conceptualization with a total of twenty-six F&R: six F&R to *Basic PMO*, ten F&R to *Intermediate PMO*, and ten F&R to *Advanced PMO*.

Table 29 – F&R identified for a PMO structure in URC context

PMO type	PMO F&R
Basic PMO	Develop and manage repositories with past R&D project's information (knowledge management)
	Ensure mentoring and coaching on the use of good project management practices by the principal investigator and her/his team
	Develop project management competences through training, workshops and seminars
	Promote social interaction, stimulating research communities/groups in order to strengthen the bonds of trust between the members of the research center
	Ensure the cohesion of the team through a clear definition of the R&D projects' objectives, as well as the research center's objectives
	Characterize the different types of R&D projects currently at the research center (e.g., collaborative university-industry R&D projects)
Intermediate PMO	Develop and implement project management methodologies adjusted to each R&D project type
	Create a platform that provides the relevant information of all past and ongoing R&D projects
	Provide, through a platform, updated information about conferences in the different research areas, as well as potential partners for research
	Implement and manage a lessons learned database so they can be incorporated in new R&D projects
	Carry out specific project management tasks to support the principal investigator (e.g., project risk management, conduction of regular progress meetings with the R&D project team)
	Provide the principal investigator with a periodic report on the current state of the R&D project, particularly in terms of scope, time and cost (e.g. project cockpit chart)
	Implement and manage a risk database associated with different types of R&D projects
	Provide software tools to support project management
	Support in the submission of applications for funding
	Support the development of technical and financial reports to submit to the funding entity
Advanced PMO	Conduct post-project reviews to ensure the exploitation of the R&D project's results (e.g., verify if the developed products have become commercialized products)
	Participate in the strategic planning of the research center, for the PMO to ensure the alignment of R&D projects with the research center strategy
	Identify, select and prioritize the new ideas for R&D projects
	Ensure the quality of the different R&D projects' management, through dashboards and audits
	Manage resource allocation between R&D project (resources capacity management)
	Seek funding for the development of R&D projects: networking and lobbying
	Conduct follow-up meetings with each R&D project team to ensure the management and project status update of the R&D projects at the research center
	Manage the allocation of human resources to research, in particular identifying areas lacking or with excess human resources, i.e., balancing the research capacities
	Monitor and control the performance of R&D projects in order to report the status of the R&D projects portfolio to the research center's board
	Manage the exploitation of the results of each R&D project (e.g., knowledge and technology transfer, namely through university-industry interface units)

RO_2: To validate the main functions and responsibilities (F&R) identified for a PMO structure in a specific URC context.

Through the data obtained with the questionnaires and interviews' phases it can be stated that the researcher was able to validate the main F&R identified for a PMO structure in URC context, specifically in the University of Minho's context. The results show that, in a general way, the proposed conceptualization fits and it is fundamental for a structure to support PM in the University of Minho's context. In more detail, the researcher was able to verify the most useful and least useful F&R identified in the proposed conceptualization. For the University of Minho's context, as identified in section 5.4.1, the most useful functions identified were *'Support the development of technical and financial reports to submit to the funding entity'*, *'Provide the Principal Investigator with a periodic report on the current state of the R&D project, particularly in terms of scope, time and cost (e.g. project cockpit chart)'*, and *'Carry out specific project management tasks to support the Principal Investigator (e.g., project risk management, conduction of regular progress meetings with the R&D project team)'*. The least useful ones were *'Manage the allocation of human resources to research, in particular identifying areas lacking or with excess human resources, i.e., balancing the research capacities'*, *'Manage resource allocation between R&D project (resources capacity management)'*, and *'Identify, select and prioritize the new ideas for R&D projects'*.

This research also shows that respondents are receptive to the creation of a PMO in their URC.

6.2 Limitations of the research

Regarding the limitations found in the development of this research, the first limitation was the existence of few studies on PMO structures in URC. The majority of the literature that has been analyzed refers to the implementation of PMO structures in a business context. Another limitation was related to the technique chosen to test the conceptualization initially proposed from the literature and that was presented to questionnaire participants. The questionnaire being developed in an online tool that, by nature, requires very specific means of dissemination, as is the case of the email. There was a difficulty either in collecting or making available the contacts of the respondents or in getting answers from the respondents and. Finally, another limitation is related to the fact that PM uses its own terminology, which creates barriers to communication, which would be too difficult for respondents, being researchers of

different areas, to understand the language used, despite the attempt of adaptation of all the functions in the questionnaire to a more common language among the respondents. This reason can explain why in the questions where the usefulness of the functions was asked, there was an average response rate of 3% for the no opinion option which may indicate a lack of knowledge of the context or a lack of understanding of the question itself.

6.3 Recommendation and suggestions for further research

As mentioned before, the implementation of support structures for PM adds value to organizations (Hobbs et al., 2008). However, the implementation of this type of structures in URC contexts is still not properly documented and substantiated, making the results of this research an important base for further research. It is true that the results of this research alone do not guarantee the correct implementation of PMO structures in URC, therefore it will be necessary to validate this conceptualization in a URC through the use of more case studies. Case studies will be very valuable, namely in understanding the weight that different URCs place on different F&R. For this, the suggestion of applying this conceptualization developed to practical URC case studies remains as future work. Also, it would be appealing to study the main challenges of implementing this kind of PMO structures and what changes occur in the overall project work when a PMO is implemented in a URC context.

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APPENDIX I – QUESTIONNAIRE FORM

Conceptualization of a project management office to support university research centers

The main goal of this survey is to study the main functions of a project management office (PMO) to support university research centers (URC). A PMO is a structure specialized in project management (PM) whose main purpose is to lead to an effective management of projects.

Individual responses will be kept anonymous and your participation is entirely voluntary. These are no risks associated with your participation. If cannot accurately provide an answer or do not feel confident about a question, please tick the box 'no opinion'. All responses will remain confidential and will be reported only anonymously for academic purposes. There are 14 questions in this survey.

1. What is the type of your URC?

Please choose all that apply and provide a comment:

- ○ Centers (please identify) _____
- ○ Institutes (please identify) _____
- ○ Labs (please identify) _____
- ○ University departments (please identify) _____
- ○ Other (please specify the type and identify) _____

2. What field is your research projects in?

Please choose only one of the following:

- ○ Social sciences and humanities
- ○ Exact sciences and engineering
- ○ Life and health sciences
- ○ Natural and environment sciences
- ○ Other (please specify): _____

3. Please state your role(s) at the URC?

Please choose all that apply:

- ○ Director
- ○ Board member
- ○ Line/research group coordinator
- ○ Senior research fellow
- ○ Research fellow
- ○ Research assistant
- ○ Administrative
- ○ Other (please specify): _____

4. Does your URC have PMO or similar structure?

Please choose only one of the following:

- ○ Yes
- ○ No

5. How would you classify the PMO at your URC concerning its functions?

Only answer this question if the answer to question 4 was 'Yes'.

Please choose only one of the following:

- ○ Supportive – It operates as a service unit: it provides administrative and operational support to projects, performs specialized tasks and gives access to information and lessons learned. The degree of control over the projects is low.
- ○ Controlling – It implements methodologies and standardized project management tools adapted to the organization, monitors compliance with the project management rules and accepted management functions under the projects that are in its domain. The degree of control over the projects is moderate.
- ○ Directive – It manages projects directly and controls all research center's projects. The degree of control over the projects is high.

6. Please indicate the total number of years that you had the following role(s):

Please choose the appropriate response for each item:

	None	< 1 year	1 – 3 years	4 – 6 years	6 – 10 years	> 10 years
Director of line/research group coordinator	○	○	○	○	○	○
Manager/coordinator of R&D project	○	○	○	○	○	○
Member of R&D project team	○	○	○	○	○	○
Other	○	○	○	○	○	○

7. Please select you age:

Please choose only one of the following:

- ○ < 30 years
- ○ 30 – 39 years
- ○ 40 – 49 years
- ○ 50 – 59 years
- ○ 60 – 69 years
- ○ > 69 years

8. Please select your gender:

Please choose only one of the following:

- ○ Female
- ○ Male

9. Please identify the utility of the following functions performed by a PMO, for improving the performance of R&D projects developed at your URC:

Please choose the appropriate response for each item:

	None	Very low	Low	Medium	High	Very high	No opinion
Develop and manage repositories with past R&D project's information (knowledge management)	○	○	○	○	○	○	○
Ensure mentoring and coaching on the use of good project management	○	○	○	○	○	○	○

practices by the Principal Investigator and her/his team							
Develop project management competences through training, workshops and seminars	○	○	○	○	○	○	○
Promote social interaction, stimulating research communities/groups in order to strengthen the bonds of trust between the members of the URC	○	○	○	○	○	○	○
Ensure the cohesion of the team through a clear definition of the R&D projects' objectives, as well as the URC's objectives	○	○	○	○	○	○	○

10. Please identify the utility of the following functions performed by a PMO, for improving the performance of R&D projects developed at your URC:

Please choose the appropriate response for each item:

	None	Very low	Low	Medium	High	Very high	No opinion
Characterize the different types of R&D projects currently at the URC (e.g., collaborative university-industry R&D projects)	○	○	○	○	○	○	○
Develop and implement project management methodologies adjusted to each R&D project type	○	○	○	○	○	○	○
Create a platform that provides the relevant information of all past and ongoing R&D projects	○	○	○	○	○	○	○
Provide, through a platform, updated information about conferences in the different research areas, as well as potential partners for research	○	○	○	○	○	○	○
Implement and manage a lessons learned database so they can be incorporated in new R&D projects	○	○	○	○	○	○	○
Carry out specific project management tasks to support the Principal Investigator (e.g., project risk management, conduction of regular progress meetings with the R&D project team)	○	○	○	○	○	○	○
Provide the Principal Investigator with a periodic report on the current state of the	○	○	○	○	○	○	○

R&D project, particularly in terms of scope, time and cost (e.g. project cockpit chart)							
Implement and manage a risk database associated with different types of R&D projects	○	○	○	○	○	○	○
Provide software tools to support project management	○	○	○	○	○	○	○
Conduct post-project reviews to ensure the exploitation of the R&D project's results (e.g., verify if the developed products have become commercialized products)	○	○	○	○	○	○	○
Support the development of technical and financial reports to submit to the funding entity	○	○	○	○	○	○	○

11. Please identify the utility of the following functions performed by a PMO, for improving the performance of R&D projects developed at your URC:

Please choose the appropriate response for each item:

	None	Very low	Low	Medium	High	Very high	No opinion
Participate in the strategic planning of the URC, for the PMO to ensure the alignment of R&D projects with the URC strategy	○	○	○	○	○	○	○
Identify, select and prioritize the new ideas for R&D projects	○	○	○	○	○	○	○
Ensure the quality of the different R&D projects' management, through dashboards and audits	○	○	○	○	○	○	○
Manage resource allocation between R&D project (resources capacity management)	○	○	○	○	○	○	○
Seek funding for the development of R&D projects: networking and lobbying	○	○	○	○	○	○	○
Conduct follow-up meetings with each R&D project team to ensure the management and project status update of the R&D projects at the URC	○	○	○	○	○	○	○
Manage the allocation of human resources to research, in particular identifying areas lacking or with excess	○	○	○	○	○	○	○

human resources, i.e., balancing the research capacities							
Monitor and control the performance of R&D projects in order to report the status of the R&D projects portfolio to the URC's board	○	○	○	○	○	○	○
Manage the exploitation of the results of each R&D project (e.g., knowledge and technology transfer, namely through university-industry interface units)	○	○	○	○	○	○	○

12. If you think there are other potential functions of a PMO, not identified before, which are important for improving the performance of the URC's projects, please list them below:

Please write your answer here: _____

13. If a PMO was created at your URC, would you be available to cooperate in the following activities?

Please choose the appropriate response for each item:

	None	Very small	Medium	High	Full	No opinion
Help create an information repository of past projects by completing a report/form for each R&D project	○	○	○	○	○	○
Collaborate with the PMO staff in improving project management practices in your R&D projects	○	○	○	○	○	○
Conduct follow-up meetings with the PMO staff, to ensure the management and to update the status of your R&D projects	○	○	○	○	○	○

14. Do you believe that the establishment of a PMO at your URC is/would be useful?

Please choose only one of the following:

- ○ Yes
- ○ No
- ○ No opinion

APPENDIX II – INTERVIEW DOCUMENTATION

Interview protocol and process

1. Present the general introduction: researcher and research context and time available for the interview.
2. The plan is to take notes and if the interviewees agree, record the interview as well.
3. Assure the interviewees that all data collected will be anonymized treated as confidential and that it will be used only for academic purposes.
4. Make it clear to interviewees that they may withdraw from the interview at any time, and in this case any data collected will not be included in the research.
5. Briefing the document will be sent before the interview, and define key terms adopted by the research, such as PMO, PMO functions and responsibilities.
6. Questions for interviewees:

- The value of having a project management structure to support your research center.
- The main functions and responsibilities of this structure to support project management.
- Identify the usefulness of the functions performed by this structure in order to improve the performance of R&D programs and projects in your research center.
- Identify the three most useful functions and the three least useful ones, and why.
- Supplementary questions will be used to prompt more detailed responses to the above questions, if appropriate.
- Characterization of interviewees, such as, academic qualifications and in which area, and experience and training in project management.

7. Advise that interviewees will receive a summary of the main findings from the interviews.
8. As soon as possible, the researcher will send by email to the interviewees a resume of the hand notes for his validation and possible additional comments.

Briefing Document

Conceptualization of a project management office (PMO) to support university research centers (URC)

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Research scope

The purpose of this research is to develop a conceptualization of a PMO structure to support URC, based on critical characteristics of the PMO, the organizational context and the experience of the researchers.

The implementation of a support structure for project management (PM) in organizations is increasingly common. Many studies have shown that organizations are looking to implement PMOs to improve their performance and ensure the strategic alignment, as the current increase and complexity of projects create new opportunities and challenges for organizations.

The PMO structure must be the change for the implementation of a project management culture through the methods, tools and techniques applied. Unsatisfactory performance of PMO structures will lead to their disappearance in the short to medium term.

There are several studies and investigations related to the implementation of support structures for PM in organizations. However, research related to the implementation of these structures in the context of URC, such as research centers, institutes and laboratories, is very limited. Thus, the research question that is required is the following: *'What are the main functions and responsibilities of a support structure for PM in URC?'*.

Thus, at this stage, your contribution will be fundamental to help characterize the functions and responsibilities to be considered in the conceptualization of a support structure for PM in URC. Thank you in advance for your willingness to conduct an interview so that this research can be fruitful.

Key PM terms adopted by the research

A support structure for PM, such as PMO, aims to support research and development (R&D) programs and projects.

The programs are defined as temporary organizations in a collaborative work environment, including a set of multidisciplinary projects related, in a specific context, with collective responsibilities and public funding support.

The functions of the PMO in URC can be grouped into two main areas:

1. Pre-award: to seek funding for programs and projects and to support the submission process, from advice to writing the proposal and coordinating the application process;

2. Post-award: assume responsibility for program or project governance, focusing on the planning stage, including examine and finalize agreements and contracts, mark and hold kick-off meetings, monitor and report the execution and closure phases and provide project management tools and resources to ensure the success of programs and projects.

Main interview questions

1. Do you perceive value in the existence of a project management structure to support your research center?

2. What are the main functions and responsibilities of this support structure for project management?

3. Identify the usefulness of the typical functions performed by the support structures for project management shown below to improve the performance of R&D programs and projects in your research center.

	None	Very low	Low	Medium	High	Very high	No opinion
Develop and manage repositories with past R&D project's information (knowledge management)	○	○	○	○	○	○	○
Ensure mentoring and coaching on the use of good project management practices by the principal investigator and her/his team	○	○	○	○	○	○	○
Develop project management competences through training, workshops and seminars	○	○	○	○	○	○	○
Promote social interaction, stimulating research communities/groups in order to strengthen the bonds of trust between the members of the research center	○	○	○	○	○	○	○
Ensure the cohesion of the team through a clear definition of the R&D projects' objectives, as well as the research center's objectives	○	○	○	○	○	○	○
Characterize the different types of R&D projects currently at the research center (e.g., collaborative university-industry R&D projects)	○	○	○	○	○	○	○
Develop and implement project management methodologies adjusted to each R&D project type	○	○	○	○	○	○	○
Create a platform that provides the relevant information of all past and ongoing R&D projects	○	○	○	○	○	○	○
Provide, through a platform, updated information about conferences in the different research areas, as well as potential partners for research	○	○	○	○	○	○	○
Implement and manage a lessons learned database so they can be incorporated in new R&D projects	○	○	○	○	○	○	○
Carry out specific project management tasks to support the principal investigator (e.g., project risk management, conduction of regular progress meetings with the R&D project team)	○	○	○	○	○	○	○

Provide the principal investigator with a periodic report on the current state of the R&D project, particularly in terms of scope, time and cost (e.g. project cockpit chart)	○	○	○	○	○	○	○
Implement and manage a risk database associated with different types of R&D projects	○	○	○	○	○	○	○
Provide software tools to support project management	○	○	○	○	○	○	○
Conduct post-project reviews to ensure the exploitation of the R&D project's results (e.g., verify if the developed products have become commercialized products)	○	○	○	○	○	○	○
Support the development of technical and financial reports to submit to the funding entity	○	○	○	○	○	○	○
Participate in the strategic planning of the research center, for the PMO to ensure the alignment of R&D projects with the research center strategy	○	○	○	○	○	○	○
Identify, select and prioritize the new ideas for R&D projects	○	○	○	○	○	○	○
Ensure the quality of the different R&D projects' management, through dashboards and audits	○	○	○	○	○	○	○
Manage resource allocation between R&D project (resources capacity management)	○	○	○	○	○	○	○
Seek funding for the development of R&D projects: networking and lobbying	○	○	○	○	○	○	○
Conduct follow-up meetings with each R&D project team to ensure the management and project status update of the R&D projects at the research center	○	○	○	○	○	○	○
Manage the allocation of human resources to research, in particular identifying areas lacking or with excess human resources, i.e., balancing the research capacities	○	○	○	○	○	○	○
Monitor and control the performance of R&D projects in order to report the status of the R&D projects portfolio to the research center's board	○	○	○	○	○	○	○

Manage the exploitation of the results of each R&D project (e.g., knowledge and technology transfer, namely through university-industry interface units)	○	○	○	○	○	○	○
Support in the submission of applications for funding							

4. Of all the functions presented, you certainly consider some more useful than others. In this sense, I ask you to identify the reasons considered for identifying the three most useful functions and the three least useful ones.

5. Your academic qualifications and in which area.

6. Your experience and training in project management.

Anonymity and confidentiality

There are no anticipated risks associated with your participation. All responses remain confidential and will be reported only in anonymous. You can withdraw from the interview at any time, and in this case any data collected will not be included in the research.

If you have any additional questions about this research before our interview, please feel free to contact me at pg28966@alunos.uminho.pt.

APPENDIX III – SPSS OUTPUTS

Correlation Matrix

Correlation	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14	V15	V16	V17	V18	V19	V20	V21	V22	V23	V24	V25
V1	1.000	0.357	0.472	0.376	0.370	0.404	0.408	0.537	0.357	0.487	0.391	0.363	0.389	0.327	0.424	0.308	0.362	0.276	0.312	0.268	0.312	0.410	0.313	0.335	0.389
V2	0.357	1.000	0.609	0.540	0.617	0.315	0.545	0.438	0.415	0.529	0.483	0.409	0.447	0.456	0.483	0.329	0.483	0.397	0.464	0.391	0.461	0.522	0.461	0.405	0.483
V3	0.472	0.609	1.000	0.451	0.475	0.266	0.528	0.437	0.422	0.546	0.448	0.372	0.448	0.514	0.488	0.283	0.399	0.304	0.413	0.312	0.370	0.466	0.400	0.299	0.338
V4	0.376	0.540	0.451	1.000	0.609	0.367	0.298	0.402	0.416	0.406	0.415	0.361	0.362	0.274	0.433	0.284	0.467	0.430	0.444	0.393	0.435	0.481	0.457	0.439	0.522
V5	0.370	0.617	0.475	0.609	1.000	0.357	0.461	0.403	0.359	0.440	0.397	0.388	0.450	0.334	0.470	0.203	0.551	0.460	0.487	0.451	0.467	0.564	0.487	0.497	0.541
V6	0.404	0.315	0.266	0.367	0.357	1.000	0.528	0.472	0.340	0.422	0.429	0.302	0.439	0.300	0.306	0.316	0.467	0.339	0.331	0.214	0.286	0.346	0.285	0.307	0.336
V7	0.408	0.545	0.528	0.298	0.461	0.528	1.000	0.521	0.462	0.654	0.634	0.615	0.616	0.633	0.540	0.422	0.566	0.419	0.511	0.393	0.401	0.551	0.466	0.468	0.409
V8	0.537	0.438	0.437	0.402	0.403	0.472	0.521	1.000	0.483	0.594	0.495	0.429	0.541	0.454	0.455	0.415	0.423	0.422	0.454	0.326	0.438	0.474	0.390	0.472	0.435
V9	0.357	0.415	0.422	0.416	0.359	0.340	0.462	0.483	1.000	0.571	0.522	0.461	0.546	0.445	0.540	0.419	0.437	0.468	0.459	0.483	0.502	0.499	0.492	0.440	0.488
V10	0.487	0.529	0.546	0.406	0.440	0.422	0.654	0.594	0.571	1.000	0.679	0.621	0.673	0.527	0.716	0.460	0.537	0.493	0.604	0.462	0.538	0.636	0.534	0.567	0.554
V11	0.391	0.483	0.448	0.415	0.397	0.429	0.634	0.495	0.522	0.679	1.000	0.749	0.570	0.564	0.630	0.635	0.551	0.541	0.557	0.512	0.552	0.607	0.526	0.559	0.507
V12	0.363	0.409	0.372	0.361	0.388	0.302	0.615	0.429	0.461	0.621	0.749	1.000	0.499	0.530	0.627	0.580	0.501	0.459	0.537	0.519	0.489	0.568	0.467	0.491	0.485
V13	0.389	0.447	0.448	0.362	0.450	0.439	0.616	0.541	0.546	0.673	0.570	0.499	1.000	0.540	0.588	0.366	0.493	0.430	0.619	0.394	0.395	0.545	0.458	0.509	0.449
V14	0.327	0.456	0.514	0.274	0.334	0.300	0.633	0.454	0.445	0.527	0.564	0.530	0.540	1.000	0.405	0.395	0.370	0.329	0.411	0.359	0.392	0.387	0.398	0.374	0.387
V15	0.424	0.483	0.488	0.433	0.470	0.306	0.540	0.455	0.540	0.716	0.630	0.627	0.588	0.405	1.000	0.428	0.591	0.527	0.619	0.501	0.503	0.663	0.518	0.525	0.609
V16	0.308	0.329	0.283	0.284	0.203	0.316	0.422	0.415	0.419	0.460	0.635	0.580	0.366	0.395	0.428	1.000	0.316	0.305	0.323	0.373	0.457	0.405	0.363	0.367	0.344
V17	0.362	0.483	0.399	0.467	0.551	0.467	0.566	0.423	0.437	0.537	0.551	0.501	0.493	0.370	0.591	0.316	1.000	0.735	0.605	0.570	0.498	0.699	0.553	0.631	0.559
V18	0.276	0.397	0.304	0.430	0.460	0.339	0.419	0.422	0.468	0.493	0.541	0.459	0.430	0.329	0.527	0.305	0.735	1.000	0.610	0.629	0.519	0.666	0.635	0.683	0.559
V19	0.312	0.464	0.413	0.444	0.487	0.331	0.511	0.454	0.459	0.604	0.557	0.537	0.619	0.411	0.619	0.323	0.605	0.610	1.000	0.604	0.512	0.668	0.664	0.779	0.630
V20	0.268	0.391	0.312	0.393	0.451	0.214	0.393	0.326	0.483	0.462	0.512	0.519	0.394	0.359	0.501	0.373	0.570	0.629	0.604	1.000	0.450	0.689	0.780	0.656	0.529
V21	0.312	0.461	0.370	0.435	0.467	0.286	0.401	0.438	0.502	0.538	0.552	0.489	0.395	0.392	0.503	0.457	0.498	0.519	0.512	0.450	1.000	0.531	0.500	0.540	0.668
V22	0.410	0.522	0.466	0.481	0.564	0.346	0.551	0.474	0.499	0.636	0.607	0.568	0.545	0.387	0.663	0.405	0.699	0.666	0.668	0.689	0.531	1.000	0.710	0.698	0.564
V23	0.313	0.461	0.400	0.457	0.487	0.285	0.466	0.390	0.492	0.534	0.526	0.467	0.458	0.398	0.518	0.363	0.553	0.635	0.664	0.780	0.500	0.710	1.000	0.709	0.581
V24	0.335	0.405	0.299	0.439	0.497	0.307	0.468	0.472	0.440	0.567	0.559	0.491	0.509	0.374	0.525	0.367	0.631	0.683	0.779	0.656	0.540	0.698	0.709	1.000	0.605
V25	0.389	0.483	0.338	0.522	0.541	0.336	0.409	0.435	0.488	0.554	0.507	0.485	0.449	0.387	0.609	0.344	0.559	0.559	0.630	0.529	0.668	0.564	0.581	0.605	1.000

Communities

Correlation	Initial	Extraction
V1	1.000	0.472
V2	1.000	0.619
V3	1.000	0.600
V4	1.000	0.610
V5	1.000	0.702
V6	1.000	0.382
V7	1.000	0.675
V8	1.000	0.546
V9	1.000	0.481
V10	1.000	0.717
V11	1.000	0.758
V12	1.000	0.691
V13	1.000	0.582
V14	1.000	0.552
V15	1.000	0.615
V16	1.000	0.561
V17	1.000	0.640
V18	1.000	0.686
V19	1.000	0.686
V20	1.000	0.709
V21	1.000	0.497
V22	1.000	0.736
V23	1.000	0.711
V24	1.000	0.742
V25	1.000	0.608

Extraction Method: Principal Component Analysis

Total variance explained

Component	Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings		
	Total	% variance	% cumulative	Total	% variance	% cumulative	Total	% variance	% cumulative
1	12.503	50.013	50.013	12.503	50.013	50.013	6.417	25.668	25.668
2	1.750	6.999	57.012	1.750	6.999	57.012	5.046	20.184	45.852
3	1.325	5.301	62.313	1.325	5.301	62.313	4.115	16.461	62.313
4	0.971	3.886	66.199						
5	0.916	3.662	69.861						
6	0.768	3.071	72.932						
7	0.696	2.783	75.716						
8	0.666	2.664	78.380						
9	0.588	2.352	80.731						
10	0.547	2.189	82.920						
11	0.484	1.937	84.857						
12	0.445	1.782	86.639						
13	0.415	1.662	88.301						
14	0.352	1.410	89.711						
15	0.332	1.328	91.039						
16	0.309	1.238	92.276						
17	0.292	1.169	93.445						
18	0.261	1.045	94.490						
19	0.247	0.989	95.479						
20	0.223	0.894	96.373						
21	0.215	0.858	97.231						
22	0.197	0.787	98.018						
23	0.193	0.770	98.788						
24	0.161	0.643	99.431						
25	0.142	0.569	100.000						

Extraction Method: Principal Component Analysis